SM113 Portable Dual-Trace Oscilloscope

Part 2 Servicing Instructions

486

MP MASTER
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SM113

Instruction Manual

OSCILLOSCOPE SM113

VOLUME 2

SERVICING INSTRUCTIONS

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PREFACE

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OSCILLOSCOPE SM 113

PART 2

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Fig. 1.1 Oscilloscope SM113

SECTION 1 - INTRODUCTION

1. GENERAL

This handbook forms Part 2 of a two-part Instruction Manual for the SM113 Portable Dual-Trace Oscilloscope. The complete manual comprises:

Part 1 - Operating Instructions

Part 2 - Servicing Instructions

Part 1 contains general information on the oscilloscope, its specifications, installation and setting-up procedures, and operating instructions for use. Part 2 contains the circuit descriptions, calibration procedures, maintenance information and parts lists.

The oscilloscope SM113 (Fig. 1-1) is a general-purpose, dual-channel, wide-bandwidth instrument. It incorporates a high-brightness tube and the controls are arranged for ease of operation. Throughout the oscilloscope, silicon transistors and integrated circuits are used to achieve high performance, long-term reliability and low power consumption. Being portable and robust, the oscilloscope is suitable for use in a large range of environmental conditions, and yet provides the accuracy and versatility required of a laboratory instrument.

2. CONSTRUCTION

The oscilloscope consists of a cruciform frame, formed by two bulkheads of sheet aluminium to which the front and rear panels are bolted. The structure is made rigid with four tie bars of extruded aluminium fitted axially between the corners of the front and rear panels. A false front panel displays the control annotations.

The cover is in one piece and is made of sheet aluminium covered in dark-grey, vinyl plastic. At the rear of the front panel, it locates into grooves and it is secured to the rear panel by four screws.

The circuit components, with the exception of the front panel controls and Y input attenuators, are mounted on four fibre-glass, printed-circuit boards. Three of these boards are hinged so that both sides can be accessible for servicing purposes; both sides of the other board are freely accessible in situ.

3. TRIGGER SYSTEM

Stable triggering is provided over the full range of the selected trigger waveform. The trigger source can be internal from either channel, internal from the supply frequency, or external. The internal channel 1 or channel 2 trigger is derived from the appropriate preamplifier via a seperate amplifier· the external trigger, if of a large amplitude, can be attenuated by a factor of 20 so that the trigger controls can operate over the whole of the waveform amplitude.

The trigger is derived from an amplified and squared portion of the selected trigger signal, this portion being determined by the slope and level controls. The edge of the signal then initiates the sweep. An integrated circuit amplifier with positive feedback is used to amplify and square the trigger input. The circuit is 'held off' after each trigger transient so that it only responds to frequencies below 5 MHz. Above 5 MHz, the circuit divides and locks on to a sub-multiple of the input frequency.

A.C. or d.c. trigger mode can be selected: an additional mode, auto, causes the amplifier to generate a trigger at a slow rate or on the mean level of the trigger input. In the absence of a trigger input, the trigger rate is dependent only on the timebase range in use.

4. VERTICAL DEFLECTION SYSTEM

The dual-channel vertical deflection system has a bandwidth of d.c. to better than 35 MHz, and 11 calibrated sensitivities from 20 mV/cm to 50 V/cm can be selected: these sensitivities can be increased by a factor of 10 but with a decrease in bandwidth. The two Y channels are very similar and dual-channel operation is obtained by electronically switching the trace on alternate sweeps of the timebase (alternate mode) or independently of the timebase at approximately 400 kHz (chopped mode). Other modes are channel 1 only, channel 2 only, and channels 1 + 2. The signal on channel 2 can be inverted when required: this facility is especially useful for differential operation.

Normal shift and fine gain controls are provided in each channel: the Y shift available is greater than 20 cm, and the fine, continuously-variable control of deflection sensitivity covers the switched ranges. On each channel, a.c. or d.c. coupling of the signal input can be selected as required. A further position of the input coupling switch connects the input to the channel to ground,

the input signal being open-circuited; this provides a ground reference level without having to disconnect the signal input.

Each channel consists of a step attenuator that provides the 11 calibrated sensitivities, and a preamplifier of high input impedance. The shift control, the fine continuously-variable gain control, and the coarse gain (x1, x10) control form part of the preamplifier.

The outputs of the two preamplifiers are fed to combining and selecting gates which are controlled by the vertical mode selection circuits. The combined deflection signal is fed via a delay line to an output amplifier and thence to the Y plates. The delay line introduces a 180 ns delay to enable the leading edge of the pulse from which the sweep trigger is derived to be displayed when internal trigger mode is selected.

5. HORIZONTAL DEFLECTION SYSTEM

The horizontal deflection system has 21 calibrated sweep rates from 0.2 μs/cm to 1 s/cm. Normal shift and fine gain controls are provided; the X shift available is greater than 20 cm, and the fine, continuously-variable control of sweep rate covers the switched ranges.

A timebase sweep is initiated when a bistable, formed by integrated logic elements, is set by a trigger signal. A bootstrap generator is gated by the bistable, and when the output of this generator reaches a defined level, the bistable is reset and held off to allow the bootstrap to recover. The hold-off time and sweep rate are both controlled by the range switch. However, the hold-off time can be varied by a small amount (HF SYNC) whenever difficulty is experienced in triggering from a high-frequency trigger signal.

An external sweep facility is provided; on this, the signal can be d.c. or a.c.-coupled, the deflection being approximately 1 V/cm. The bandwidth of the X amplifier is greater than 2 MHz.

6. CATHODE RAY TUBE

The cathode ray tube has a rectangular display area of 10 cm x 8 cm and an internal graticule to minimise parallax errors of measurement. A beam-rotate control permits the trace to be aligned with the graticule. Horizontal and vertical deflection is obtained electrostatically and the p.d.a. voltage is

approximately +10 kV with respect to the cathode. Controls to adjust the focus and brilliance and to minimise astigmatism are provided.

7. CALIBRATOR

A calibrator provides two 1 kHz square-wave outputs of 100 mV and 1 V for checking the horizontal and vertical deflection systems, or for use as external triggers to auxiliary equipment. The voltage and frequency limits (± 2% and ± 1%, respectively) are valid over the range -10 deg C to +50 deg C.

8. POWER SUPPLIES

The oscilloscope can be operated either from an a.c. supply (voltage ranges, single phase: 180 V - 260 V or 90 V - 130 V; frequency 45 Hz to 440 Hz) or from a 20 V - 30 V battery. Battery operation is either from its own attached 4-hour pack accessory or from an external d.c. supply. Power consumption on a.c. operation is approximately 50 W; on battery operation it is approximately 30 W.

The h.t. and e.h.t. supplies are derived from a d.c.-to-d.c. converter that operates from a nominal 24 V d.c. supply. This supply, on mains operation, is generated via a transformer with a low-voltage secondary winding, and a rectifier and voltage stabiliser.

SECTION 2 - TECHNICAL DESCRIPTION

CODING

1. The Oscilloscope SM113 contains six wired-in sub units, which are coded as follows:

	Code
Power unit	X1
Trigger, sweep generator and X amplifier	X2
Y-Amplifier	X3
Vertical output amplifier	X4
CH1 attenuator	X5
CH2 attenuator	X6

2. Throughout this manual any component mounted on one of these units is identified, for clarity, by an appropriate code-number prefix (based on the component reference) followed by the circuit reference number. For example, 3D13 refers to D13 in the Y-amplifier X3. Components with no prefix are mounted on the main assembly. The code prefixes do not appear on the silk-screening of the units.

SYSTEM DESCRIPTION

3. Figure 2-1 shows an overall block diagram of the instrument and illustrates the interrelation of the main functional units and front-panel controls. The following description is written mainly around Fig. 7-1, Block Schematic, which illustrates the interrelation of the various systems that form the oscilloscope.

Vertical Deflection System

4. The two signal channels are similar and the outputs of each channel are switched, dependent upon the vertical mode selected via a delay line and a vertical output amplifier to the c.r.t. Y plates. Signal channel 1 only is described in Para. 5 to 7; differences relating to signal channel 2 are described in Para. 8; vertical mode switching, the delay line and the vertical output stage are described in Para. 9 to 12.

5. The input signal to CH1 is connected to CH1 IN (SKT F) and thence, via input coupling switch (SN), to switched attenuator V/cm (5SA) which provides eleven attenuation ratios (from 1:1 to 2500:1). This attenuator presents constant input impedance and input capacity on all eleven ranges. From the attenuator, the signal is fed to an impedance changer, 3VT1 and 3VT2, the main component being a field-effect transistor. Any d.c. shift in the c.r.t. display, between short-circuit and open-circuit input conditions, is minimised in this stage by a preset control.

6. The pre-amplifier comprises a long-tailed pair with a constant-current source, and part of a balanced cascode amplifier. In addition, a trigger pick-off circuit, comprising a balanced amplifier and an output amplifier, applies a sample of the input waveform to the trigger source switch (SC). A selected portion of this waveform sample can then be used to trigger the sweep in the sweep generator. The remaining part of the cascode output amplifier is common to both signal channels, forms part of the vertical output amplifier, and is switched into circuit dependent upon the vertical deflection mode selected.

7. Several front-panel controls are associated with the pre-amplifier (see Fig. 2-1), of which SET GAIN and BALance are preset controls. Other, internal, controls allow the x10 gain and coarse balance to be preset: adjustment for frequency compensation is also provided.

8. Signal channel 2 is similar to channel 1, but an additional front-panel control (PULL TO INVERT) is incorporated in the cascode amplifier. This control, a change-over switch, changes the sense of the output from the first part of the cascode amplifier thus providing an effective signal inversion when required.

9. The signal applied via the delay line to the common part of the cascode amplifier can be:

   (a) from one of the signal channels (CH1 or CH2 modes).

   (b) switched alternately from each channel (ALT or CHOP modes).

   (c) composite, from both channels (CH1 + 2 mode).

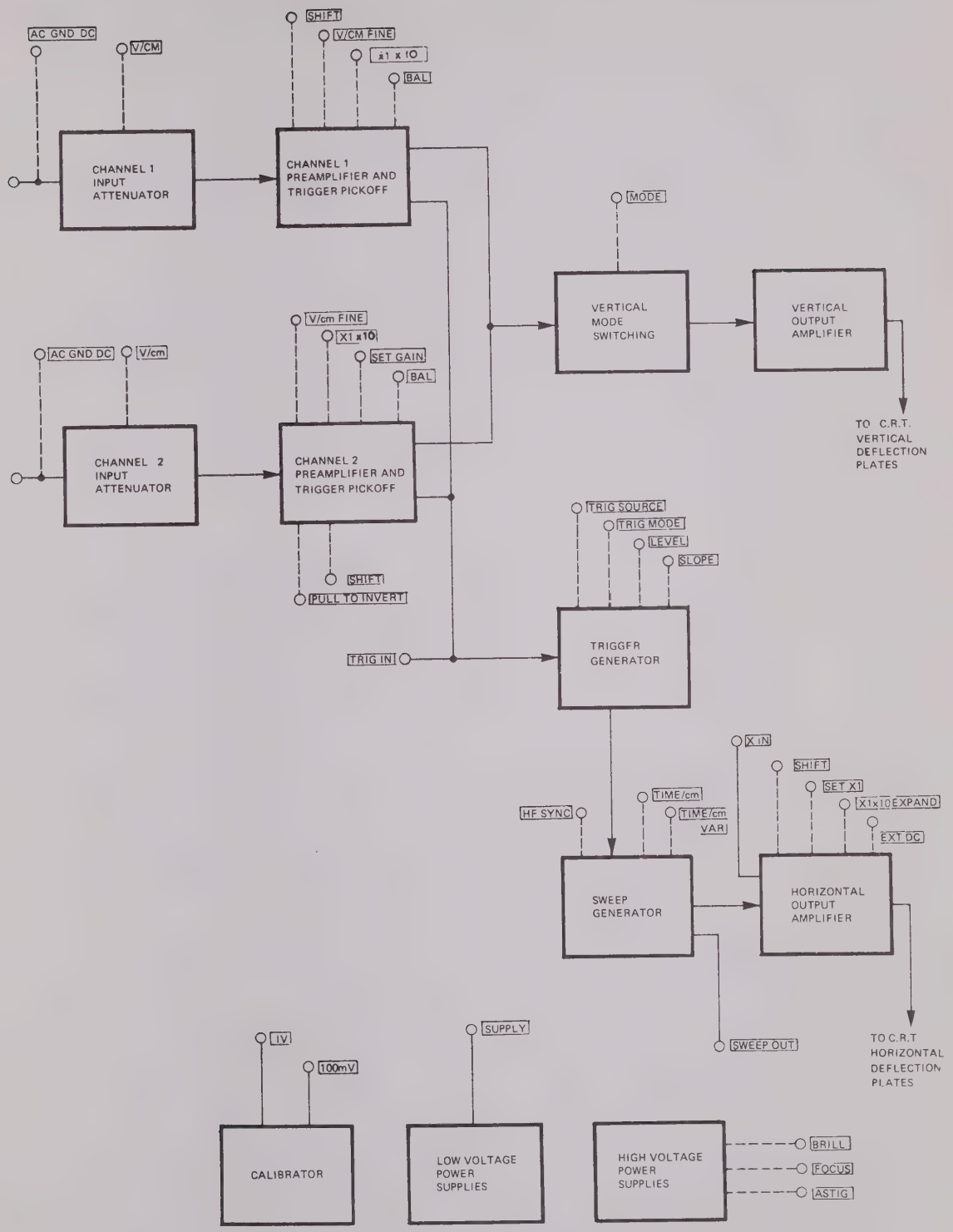


FIG. 2-1 OVERALL BLOCK DIAGRAM

10. In modes other than the CHOP mode, the vertical mode oscillator (3VT29, 3VT30 and 3VT32) is inoperative, while in modes other than the ALT mode, the alternate-mode trigger shaper (2VT20) is inoperative. In all modes, the biasing level of the vertical mode bistable (3VT27, 3VT38) is determined by the MODE switch, as follows:

(a) CH1, biased such that a gating input is fed to the two switched linear gates 3D3, 3D4 and 3D2, 3D5. Thus only CH1 signals are fed to the vertical output amplifier via OR gates 3D4, 3D14 and 3D5, 3D15.

(b) CH2 biased such that a gating input is fed to the two switched linear gates 3D13,3D14 and 3D12, 3D15. Thus only CH2 signals are fed to the vertical output amplifier via OR gates 3D4, 3D14 and 3D5, 3D15.

(c) CH1 + 2, biased such that a gating input is fed to all four switched linear gates. Thus CH1 and CH2 signals are fed to the vertical output amplifier via the two OR gates.

(d) ALT. The MODE switch removes a bias from the alternate mode trigger shaper, the output of which then sets and resets the bistable on alternate timebase sweeps. The gating input to the pairs of switched linear gates changes accordingly, and thus CH1 then CH2 signals are fed, via the two OR gates, to the vertical output amplifier on alternate timebase sweeps.

(e) CHOP. In this case, the vertical mode oscillator switches the bistable independently of the timebase at approximately 200 kHz. The gating input to the pair of switched linear gates changes accordingly, and thus CH1 and CH2 signals are fed, via the two OR gates, to the vertical output amplifier many times per timebase sweep.

11. Whenever the bistable changes state on the CHOP vertical mode, the chop oscillator provides an input, via emitter follower 2VT12, to the c.r.t. blanking amplifier to blank the c.r.t. during the switching period.

12. The output from the combining and selecting gate diodes is fed to the vertical output amplifier via a delay line, DL1. This introduces a 180 ns delay to enable the leading edge of the pulse from which the sweep is derived to be displayed when internal trigger mode is selected. The vertical output amplifier consists of the common part of the cascode amplifier (Para. 6), this being coupled via

emitter followers to a balanced cascode output amplifier. An internal control provides adjustment for frequency compensation.

Trigger System

13. The required trigger signal is selected by the TRIG SOURCE switch (SC) and fed, via an input coupling switch (SD), to an impedance changer (2VT1 and 2VT2) of which the main component is a field-effect transistor.

14. The trigger generator consists of a high-gain differential amplifier (2N1) connected as a d.c. operated switch (Schmitt trigger), and a pulse shaper (2VT3 and 2N2-1). The polarity of the input to the Schmitt is controlled by the SLOPE control. The circuit divides at input triggering frequencies of approximately 2 MHz and above. When auto mode is selected, negative feedback is applied, via an integrating network, and the circuit then switches as the resultant triangular feedback waveform just passes through the hysteresis levels of the Schmitt trigger.

Horizontal Deflection System

15. The timebase is controlled by the sweep bistable (2N2-2 and 2N2-3). This bistable is set by the sweep trigger, is reset at the end of the scan, and is then clamped for a hold-off period to allow the flyback to be completed before retriggering occurs.

16. During the wait period (i.e. the period between the end of hold-off and retriggering) the output of the bistable is reset at a positive level. Thus the output of inverter 2N4-4, in turn, changes to logic 0, therefore the capacitor selected by the TIME/cm switch (SH) is fully discharged.

17. The selected capacitor, 2VT15, 2VT16, 2VT18 and 2VT19 form a bootstrap sweep generator in which the constant-voltage power supply is controlled by RV4 (TIME/cm VAR).

18. The timebase sweep is initiated by the sweep trigger which sets the bistable so that the output of inverter 2N4-4 changes to a positive logic level at pin 13. The selected sweep capacitor now begins to charge linearly, the charging current being set by the constant-voltage power supply and the selected resistor.

19. At a predetermined point, the output of the sweep hold-off (2N2-4, 2VT17, 2VT20) changes from a positive level to a 0 V level. This resets bistable 2N2-2

and 2N2-3 and the output from 2N4-4 reverts to a logic 0 level, whereupon it rapidly discharges the selected sweep capacitor. The hold-off period required is dependent upon the time that the capacitor requires to discharge through R88 and, at the end of the hold-off period, the output of the sweep hold-off reverts to a positive level. Thus bistable 2N2-2 and 2N2-3 can be set by the next sweep trigger.

20. If a sweep trigger occurs near the instant the hold-off period ends (e.g. at high triggering frequencies), then the hold-off period can be adjusted by RV3(HF SYNC) to obtain a stable display.

21. The input to the X amplifier (2VT22 to 2VT28) is controlled by the TIME/cm switch (SH); on external modes, the input is obtained from SKT E (X IN); on internal mode, the input is obtained from the sweep generator. 2VT22 to 2VT28 form a cascode amplifier which provides a balanced output to the c.r.t. X plates. 2VT21 provides the high input impedance necessary when external sweep mode is selected.

22. When the sweep bistable (2N2-2 and 2N2-3) is reset, the positive-going change of level at 2TP7 is shaped by 2N4-1 and fed as the alternate-mode trigger waveform, to the vertical mode bistable (Para. 10(d)). In addition, this change of level, inverted by 2N3-1 is fed via the series resistor R18, as a blanking input to the c.r.t. blanking modulator (2VT4 to 2VT6), the other input being fed from the chopped-blanking emitter follower 2VT12 (para. 11). Blanking is therefore applied to the c.r.t.:

(a) at the end of sweep

(b) whenever the chop oscillator changes state (i.e. CHOP mode).

CIRCUIT DESCRIPTION

Trigger (Fig. 7-3, Sheets 1, 2 and 3)

23. The selected trigger input is applied to the gate of field-effect transistor 2VT1, the operating condition of which is set by 2RV8 (EXT. TRIG. CENTRE), so that the quiescent level at 2TP1 is 0 V. Overload current limiting is provided by 2R2 and 2D1 which, in addition, prevent damage to 2VT1 by large-amplitude trigger pulses. Capacitor 2C1 is for speed-up purposes. A large amount of negative feedback is applied to 2VT1 by 2VT2 and 2R5 to reduce the output impedance of

2VT1. The high-frequency sensitivity of the trigger circuit is reduced when vertical mode CHOP is selected. Gates N3/3, N4/2 provide a low-impedance path via 2C30 for any high-frequency components in the trigger signal (i.e., edges derived from the chop-oscillator waveform, in particular) thus preventing incorrect triggering in the CHOP mode.

24. Integrated circuit 2N1 is a high-gain differential amplifier to which positive feedback is applied via 2R12, in parallel with 2C5 and 2R106, the circuit operating as a d.c. operated switch (Schmitt trigger) in which the switching levels are defined by 2R12 and the source impedance presented to pin 3 of 2N1. Diodes 2D13 and 2D14 in conjunction with 2R44 provide input voltage limiting to the amplifier. Negative feedback may also be applied integrated by 2R13 and 2C4, via 2R9 (Para. 25(b)).

25. The generation of a trigger event at the output of 2N1 (2TP6) is dependent upon the trigger mode selected: the circuit operation is therefore best explained with reference to the simplified diagrams of Fig. 2-2(a), (b).

(a) A.C. and d.c. trigger mode (Fig. 2 2(a)). The auto feedback loop, 2R13, 2C4 and 2R9, is inhibited by SDc and the input to 2N1 consists of the trigger waveform to which a d.c. level, set by the level control (RV1) has been added. The setting of SE determines the slope of the trigger waveforms on which 2N1 switches: the hysteresis points are defined by 2R12 and 2R45 if negative slope is selected, and by 2R12, 2R45 and 2R6 if positive slope is selected. 2N1, therefore, is switched at a point on the required slope of the trigger waveform set by the level control, i.e. this point is d.c. shifted about 0 V, approximately.

The output at 2TP6, consists of a positive-going event, coincident with the selected part of the trigger waveform, of which the maximum p.r.f. is determined by the time constant 2C5 and 2R45 (negative slope selected) or 2C5, 2R45 and 2R6 (positive slope selected). This p.r.f. is approximately 3 MHz, and if the p.r.f. of the trigger input exceeds this frequency the trigger is counted down. This prevents loss of sweep trigger at frequencies above the maximum frequency at which 2N1, 2VT3 and 2N2 can operate.

(b) Auto trigger mode (Fig. 2-2(b)). In this mode, negative feedback integrated by 2R13 and 2C4, is applied to pin 4 (the inverting input) of 2N1. The resultant integrated waveform at pin 4 is triangular, and rises and falls within the upper and lower hysteresis levels of the d.c. operated switch. When the level of the waveform reaches either of the two hysteresis levels, the switch changes state.

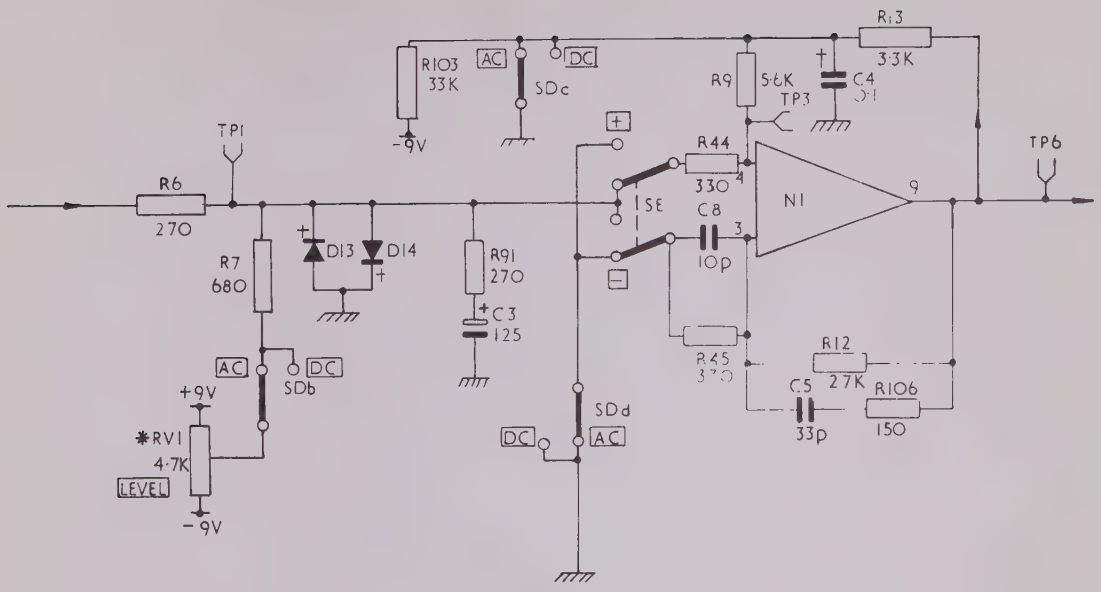
The d.c. level of both inputs of 2N1 is approximately 0 V, i.e. that at 2TP1 (Para. 23), as the d.c. component of any trigger input present is removed by C3 (SDa being in the AUTO position). The a.c. component of the trigger signal, however, is fed to one input, only, of 2N1, 2C3 removing this component from the other input.

The inverting input of 2N1 is therefore a triangular waveform, centred about 0 V: the a.c. component of the trigger signal from 2R44 is superimposed upon this waveform (negative slope selected), or upon the in-phase input, pin 3 (positive slope selected). Hence, although the auto trigger rate is dependent upon the time constant 2R13, 2C4, it is also dependent upon the amplitude and p.r.f. of the trigger signal. However, the p.r.f. of the trigger signal must be greater than that of the free-running auto trigger rate. On the slower timebase ranges (1 s/cm to 0.2 ms/cm), C13 is placed in parallel with 2C4, by wafer SHf of the TIME/cm switch. This ensures that the auto trigger rate is commensurate with the selected timebase sweep.

26. 2VT3 is a pulse shortener and 2N2-1, a pulse shaper, performs a'positive NAND' function. A truth table is shown below, referring to gate 2N2-1 in Fig: 2-3.

Input (1)	Input (2)	Output (3)
0	1	1
1	1	0
1	0	1

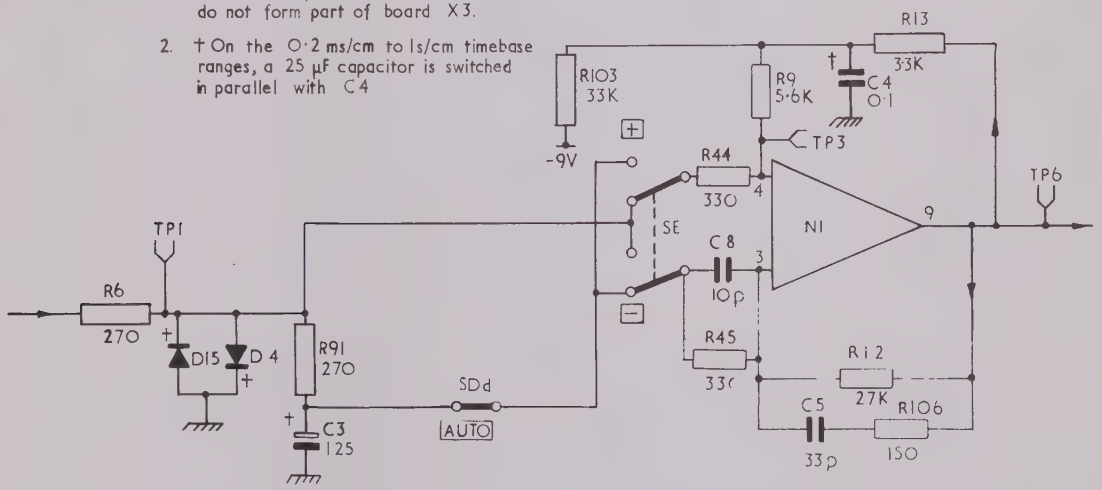
In the period before a positive-going trigger event at 2TP6 occurs (Para. 25(a)), 2VT3 is non-conducting: pins 1 and 2 of 2N2-1 are therefore at logic 0 and logic 1 respectively, so that pin 3 is at logic 1 (i.e. positive level). When 2TP6 becomes positive, 2VT3 conducts, pin 1 changes to logic 1 and pin 3 falls to logic 0 for a period determined by the time constant 2R15, 2C6. After this period, pins 4 and 5 of 2N3-2 assume logic 1 and pin 2 of 2N2-1 falls to logic 0, and pin 3 returns to logic 1 and remains at this level as 2N1 switches back to the wait state.



(a) A.C. OR D.C. TRIGGER MODES (AC.MODE SHOWN) SIMPLIFIED DIAGRAM.

Notes. 1. * These components (and all switches) do not form part of board X3.

2. † On the 0·2 ms/cm to 1s/cm timebase ranges, a 25 µF capacitor is switched in parallel with C4



(b) AUTO TRIGGER MODE – SIMPLIFIED DIAGRAM.

OPERATION OF THE TRIGGER CIRCUIT.

MODE SELECTION

Thus a trigger pulse, 100 ns in duration, is generated at 2TP5 for every positive-going transition at 2TP6.

Horizontal Deflection System (Fig. 7-3, Sheets 1-4)

27. Logic packages. The SN7400N (or FJH131) package used in the trigger and sweep generator circuits perform a positive NAND function, i.e. if all inputs to a gate are logic 1(not less than +2.4 V), the output will be logic 0(not greater than +0.4 V). For all other input conditions, the output will be logic 1. Fig. 2-3 and Table 2-1 show the sequence of operation of the package for all possible inputs.

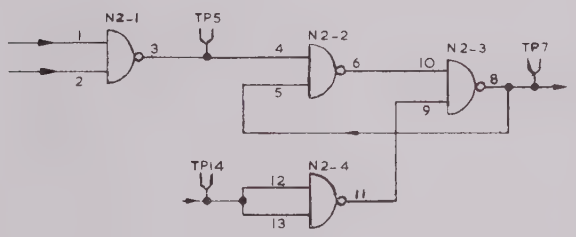


FIG. 2-3 INTEGRATED PACKAGE - LOGIC DIAGRAM

Element and pin Nos.		Wait or end of hold-off	On trigger	During sweep	End of sweep or during hold-off
	1	1 or 0	1	1 or 0	1 or 0
N2-1	2	0 or 1	1	0 or 1	0 or 1
	3*	1	0	1	1
	4	1	0	1	1
N2-2	5	1	0	0	1
	6*	0	1	1	0
	8*	1	0	0	1
N2-3	9	1	1	1	0
	10	0	1	1	0
	11*	1	1	1	0
N2-4	12	0	0	0	1
	13	0	0	0	1

*element output pin

TABLE 2-1 SEQUENCE OF OPERATION

28. Sweep generator. During the wait period (i.e. the period between hold-off and re-triggering), the output of 2N2-4, the input at pin 4 of 2N2-2 and the output of 2N2-3 are each at logic 1. Since both inputs of 2N4-4 are also at logic 1, the output of 2N4-4 is at logic 0 and thus the capacitor selected by wafer SHd of the TIME/cm switch is fully discharged.

29. The timebase sweep is initiated by the sweep trigger: this sets the bistable; the output of 2N2-3 changes to logic 0 and the output of 2N4-4 reverts to logic 1. The selected sweep capacitor now begins to charge linearly through one of the resistors R8 to R13, the charging current being set by the constant-voltage power supply 2VT18, 2VT19. This constant voltage is itself determined by one of the resistors 2RV4, 2R55, 2RV6 or 2RV5, depending on the selected sweep, to allow for tolerances on the sweep capacitors.

30. Commencing at the slowest timebase ranges, the first three positions of wafers SHd and SHe each cover six ranges, and wafer SHa inserts R8 to R13, in turn, into the charge path as the TIME/cm switch selects a faster range. The fourth position of wafers SHd and SHe covers the three fastest timebase ranges, and wafer SHb inserts R11 to R13, in turn, into the charge path, the charging capacitor being 2C17 alone. The effect of this capacitor in parallel with 2C14, 2C15 or 2C16 is offset by 2RV4, 2R55 and 2RV6.

31. The output of drain follower 2VT15 is fed via emitter follower 2VT16 to hold-off circuit 2VT17 and monostable 2N2-4, 2VT20, and also via SHg to the X amplifier.

32. During the wait and sweep periods 2VT20 is conducting, and the input to 2N2-4 is held at logic 0. The length of sweep is set by 2RV3 so that when the base of 2VT17 has risen to approximately +2 V (i.e. logic 1 at pins 12 and 13 of 2N2-4), the output of 2N2-4 changes to logic 0. This resets bistable 2N2-2, 2N2-3, 2N4-4 output assumes logic 0 and rapidly discharges the selected sweep capacitor.

33. The hold-off required is dependent upon the time that the selected sweep capacitor takes to discharge through R88. 2R61 and 2C19 in parallel with the capacitor selected by wafer SHe form the time constant for the hold-off period (on the three fastest timebase ranges, 2C19 only, is the selected capacitor), and the end of hold-off is controlled to provide stable sweep triggering. Positive-going pulses, derived from the logic 1 outputs at pin 6 of 2N2-2 which occur when triggers are

generated during hold-off, are applied to 2VT20 emitter via 2C31 and 2R97. These pulses prevent the monostable from reverting to its stable state near or during the instant a trigger occurs. However, at high triggering frequencies, additional control is provided by RV3 (HF SYNC). This enables the aiming potential, and thus the hold-off period, to be adjusted so that the next sweep is not initiated immediately the hold-off period ends.

34. X amplifier. The sweep waveform at 2TP8 is fed, via SHg (SH set to INT SWEEP) and source follower 2VT21, to the X amplifier (2VT22 to 2VT28), which converts the single-ended input at 2VT23 to a balanced output to the c.r.t. X plates. The operating conditions of the amplifier are such that the mean potential of the X plates is similar to that of the Y plates. 2C27 and 2R28 provide high-frequency compensation.

35. When SG is switched to x1, the overall gain of the sweep generator and X amplifier is determined by RV5 (CAL x1), RV4 (TIME/cm VAR) being set to CAL. RV5 is set on the 10 ms/cm range, the voltage of the constant-voltage power supply then being determined by 2R55. The x5 gain is then adjusted accordingly.

36. If SH is set to the X IN DC position, 2VT21 provides a high input impedance, via wafer SHg, to an input at SKT E. This is a front-panel socket which permits the connection of an external timebase.

37. C.R.T. modulation. 2VT4 to 2VT6 form a modulation pulse generator consisting of a d.c. amplifier (2VT4 and 2VT6) and a complementary current switch (2VT5). There are two inputs to each section of the pulse generator, these being the sweep gating waveform via emitter follower 2VT15 and chopped-blanking gating via emitter follower 2VT12.

38. 2RV1 is adjusted so that a modulation level of approximately +9 V (i.e. maximum brightness) applied to the c.r.t. blanking plate, unblanks the c.r.t. during the sweep period, or, if CHOP vertical mode is selected, on the positive-going excursions of the chopped-blanking waveform during the sweep period. The gain of the d.c. amplifier to the sweep gating and chopped-blanking inputs is approximately 6 and 12, respectively.

39. The edges of the input waveforms, after differentiation by 2C7, 2R23 or 2C8, 2R23, rapidly switch the current in 2VT5 (and thus 2VT6) to improve the rise and fall times of the modulation pulse. 2C10 provides an additional current source

for 2VT5 as this transistor is switched into heavier conduction on removal of the blanking from the c.r.t. The improvement in rise and fall times ensures that the c.r.t. is rapidly unblanked and blanked at the beginning and the end of a timebase sweep, or, on CHOP vertical mode, as chopped switching occurs.

Vertical Deflection System

40. The vertical deflection system consists of two identical channels (CH1 and CH2), each of which comprises an attenuator sub-unit (CH1 - attenuator X5: attenuator X6), a pre-amplifier and a trigger pick-off amplifier. The outputs of each channel are switched, dependent upon the vertical mode selected, via a delay line and a vertical output amplifier, X4, to the c.r.t. Y plates. The following description of the attenuator, pre-amplifier and trigger pick-off refers to channel 1 only; that of the signal selection and the output amplifier includes the signals of both channels.

41. Attenuator (Fig. 7-4, sheet 1). The input signal is fed via SKTF (CH1 IN) and SN (input coupling) to wafer 5SAa of the CH1 V/cm switch. On the 0.02 V/cm range of 5SA, the signal is fed, unattenuated, via the four wafers 5SAa to 5SAd, to source follower 3VT1 in the pre-amplifier on all other ranges it is attenuated by amounts varying from 2.5:1 on the 0.05 V/cm range to 2500:1 on the 50 V/cm range. For example, on the 5 V/cm range, the signal is first attenuated by 100:1 in the network in which 5R3 is the series resistor, then further attenuated by 2.5:1 in the network in which 5R8 is the series resistor, parallel loading by the 1 megohm input resistance of the subsequent network being considered in each case.

42. Trimming capacitors 5C3, 5C7, 5C11, 5C15 and 5C18 provide frequency response compensation by equalising the series and shunt time constants. Trimming capacitors 5C1, 5C5, 5C10, 5C13, 5C16 and 3C1 allow a constant input capacity to be maintained independent of the range selected, thus allowing the use of an external probe.

43. Channel 1 preamplifier (Fig. 7-5). The input signal, suitably attenuated, is fed to the gate of source follower 3VT1 to which negative feedback, to reduce the output impedance, is applied by 3VT2. 5R12 is an overload current limiter and prevents damage to 3VT1 by large-amplitude inputs while 5C19 is a speed-up capacitor. 3D1 provides further protection for 3VT1. Any gate leakage current

is offset by 3RV1 such that the output of the pre-amplifier, and thus the d.c. level to the c.r.t. does not change between short-circuit and open-circuit input conditions.

44. The signal at 3VT3 base is converted into a balanced output by differential amplifier 3VT3 to 3VT5, in which 3VT4 forms a constant-current source. The potential at 3VT5 base is determined, via emitter follower 3VT6 and 3VT33, by 3RV3 (coarse balance), RV6 (BAL) and 5RV1 (shift). 3VT33 and 3VT6 have similar temperature coefficients and thus 3VT5 base is maintained at the level set by 3RV3 and RV6, minimising drift. These two controls enable the amplifier to be balanced so that the trace does not shift when switch SJ is operated.

45. The outputs from 3VT3 and 3VT5 are fed, via emitter followers 3VT7 and 3VT8, to 3VT9 and 3VT10 which, in conjunction with 4VT1 and 4VT3, form a cascode amplifier. RV8 (V/cm FINE) provides continuously-variable control of the gain over a range in excess of 2.5:1 and, in the fully-clockwise position (CAL), direct measurement of the input signal can be made in conjunction with 5SA, (Note: In channel 2, operation of 3SL (PULL TO INVERT) changes the sense of the output from 3VT22 and 3VT23 and so provides signal inversion, when required, on this channel).

46. The outputs from emitter followers 3VT7 and 3VT8 are also fed to trigger pick-off amplifier 3VT11, 3VT12. 3VT11 acts as a current source for virtual-earth amplifier 3VT13, the gain of which is determined by the negative-feedback resistor 3R43. The d.c. level at 3PT6 (3VT13 emitter) is 0 V, set by 3RV7 (trigger centre), so that the input conditions of the trigger generator on d.c. trigger mode are maintained constant, independent of the trigger source selected.

47. Signal selection. The signal applied via delay line DL1 to the vertical output amplifier can be: from one of the signal channels (CH1 or CH2 modes); composite, from both channels (CH1 + 2 mode); switched alternately from each channel (ALT or CHOP modes). In all modes the biasing level of bistable 3VT27 and 3VT28 is controlled by SM (MODE), the bistable then determining the state of the combining and selecting gates 3D2 to 3D5 (channel 1) and 3D12 to 3D15 (channel 2).

(a) CH1 (Fig. 2-4(a)). 3VT27 base is returned via 3R90 and SMb to -40 V, and 3VT28 base is returned via 3R91 and SMa to -9 V. No triggering input is present at 3TP18, the chop oscillator, 3VT29 and 3VT30, being held inoperative by SMc and the alternate trigger shaper, 2VT10, being held in a non-conducting state by SMd, 3VT27 and 3VT28 are therefore held in one state, with 3VT27 non-conducting and 3VT28 fully conducting. 3D2 and 3D3 are thus reverse biased with 3D4 and 3D5 forward biased, while 3D12 and 3D13 are forward biased and 3D14 and 3D15 reverse biased. The channel 1 signal, only, is thus fed to the vertical output amplifier.

(b) CH2 (Fig. 2-4(b)). In this mode the circuit action is similar to that of channel 1 but the biasing of 3VT27 and 3VT28 is reversed, 3VT27 base being returned to -9 V and 3VT28 base to -40 V. This, in turn, changes the biasing conditions of the combining and selecting gates, and thus the channel 2 signal, only, is fed to the vertical output amplifier.

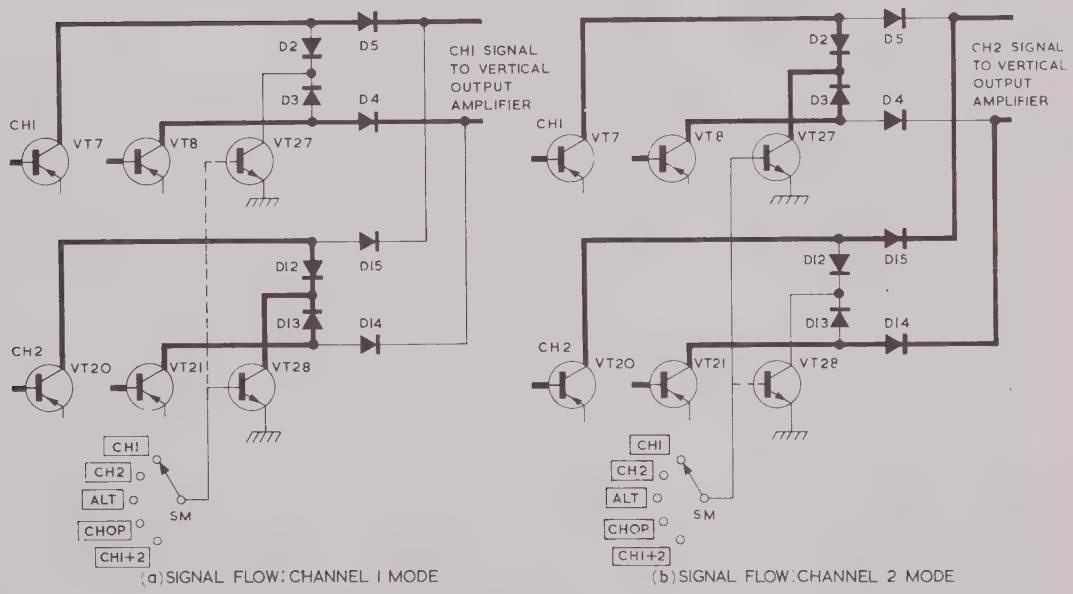


FIG. 2.4 COMBINING AND SELECTING GATING(SIMPLIFIED DIAGRAMS): EFFECTIVE SIGNAL PATHS

(c) CH1 + 2. SMa and SMb return the bases of 3VT28 and 3VT27 to -40 V so that each transistor is biased into non-conduction. 3D2, 3D3, and 3D12, 3D13 are then reverse biased with 3D4, 3D5 and 3D14, 3D15 forward biased, so that the output, at 3TP9 and 3TP10, consists of a composite channel 1 and channel 2 waveform. 3R99 is switched in parallel with 3R36 by SMd to offset, by potential division, the effect of the increase in bias on 4VT1 and 4VT2 due to the increase in current through 3R33, 3R39, 4R2, 4R3 and these transistors, as the two channels are switched into circuit.

(d) ALT. In this mode SMd removes the bias from 2VT10, and SMa and SMb return the bases of 2VT28 and 2VT27 to -9 V. Negative-going pulses at 3TP18, derived via 2C12, 2R40 and 2VT10 from the change in level to logic 1 at 2TP7 (2N2-3 pin 8) at the end of sweep, are differentiated by 3C29, 3R89 and 3C31, 3R93. The negative-going component, fed via 3D19 and 3D20 to 3VT27 and 3VT28 bases, switches the relevant conducting transistor into non-conduction and the bistable changes state. Any transients generated during switching therefore occur during the timebase hold-off and wait period (i.e. c.r.t. blanked).

(e) CHOP. The current path for 3VT30 is completed via SMc in this mode, 3VT29 and 3VT30 then forming an emitter-coupled astable of approximate p.r.f. and mark-to-space ratio of 200 kHz and 3:1 respectively. During the switching period, negative-going 1, 2 μs pulses from 3VT30 (3TP20) are fed via emitter follower 2VT12 to the c.r.t. modulation circuit. Similar pulses (3TP18), inverted by 3VT32 from the output of 3VT29(3TP19) are fed to 3VT27 and 3VT28 and switch the bistable as described in Para. 47(d), i.e. switching during c.r.t. blanking. The chopped portions of the signals displayed on each channel are thus approximately 3.7 μs in duration.

48. Output amplifier. 4VT1 and 4VT3 form the common part of the cascode amplifier in conjunction with 3VT9, 3VT10 (channel 1) or 3VT22, 3VT23 (channel 2). Negative feedback, applied via 4VT2, 4R7 and 4VT6, 4R24, maintains the d.c. conditions of the amplifier and thus of the balanced output to the c.r.t. Y plates. The gain of output cascode amplifier 4VT4, 4VT5, 4VT7 and 4VT8 is determined by 4R14; the remaining components coupling the emitters of 4VT4 and 4VT8 provide frequency compensation.

Power Unit (Fig. 7-6)

49. The input line supply is connected to PLA, switched by SA, fused by FS1, and connected via the voltage selector switch SB, dependent upon the supply voltage, to the primary windings of T1. The output of T1 is full-wave rectified by D2 and D3 to provide a d.c. voltage of approximately +24 V at pin 1.

50. Transistors VT1, VT2 (mounted on the rear panel of the oscilloscope) and 1T1 form a conventional d.c./d.c. converter which oscillates at approximately 3 kHz. The input supply voltage across pins 2 and 3 is dependent upon the voltage drop across series regulator VT3 (Para. 51) due to the load current. With the exception of the c.r.t. heater circuit, the outputs of the secondary windings of 1T1 are rectified as follows:

(a) +9 V: full-wave rectified by 1D6

(b) -9 V: full-wave rectified by 1D6

(c) +9 kV: voltage multiplied by 1D10 to 1D15

(d) -1.35 kV: voltage multiplied by 1D16 to 1D19 and 1VT6, 1VT7.

(e) +125 V: half-wave rectified by 1D20

(f) +75 V: half-wave rectified by 1D21

(g) -40 V: half-wave rectified by 1D22

(h) +20 V: half-wave rectified by 1D23.

51. Stabiliser. Voltage control is provided by 1VT1 to 1VT5 and VT3. The input at 1VT5 base consists of a sample portion of the +20 V output voltage provided by potential divider chain 1R12, 1R13 and 1R14, and of a sample portion of the +9 V output voltage before smoothing. The current in 1VT5 (and thus in 1R5) is determined by these inputs and any transient variations (a.c.) in the +20 V or +9 V lines or long-term variations (d.c.) in the +20 V line cause a proportional change in current in 1VT2. 1VT3 provides a constant-current source for 1VT1 and 1VT2, this current being the sum of 1VT1 base current and 1VT2 collector current. 1VT1 base current is thus the difference between the constant current and the generated error current. Emitter follower 1VT1, in turn controls series regulator VT3 so that an increase in current in 1VT5, due to a negative-going fluctuation on the +9 V or +120 V lines, causes an increase in the conduction of VT3. Since VT3 is

effectively in series with the converter output, the decrease in its impedance (i.e. increase in output voltage) tends to counteract the reduced input voltage to 1VT5. Conversely, if the input to 1VT5 increases, the impedance of VT3 will be increased. Any tendency for 1VT5 current to drift is offset by 1VT4, an identical transistor type, in which the forward-biased base-emitter junction is used for temperature compensation. The characteristics of 1D1 and 1D2 are also used to maintain the constant-current source with temperature.

52. Voltage stabilisation of the e.h.t. supply is achieved by transistors 1VT6 and 1VT7 controlled by 1R24, part of the voltage divider chain between the +20 V rail and the -1.35 kV output.

53. Battery operation. When the oscilloscope is operated from an external battery or from the Battery Pack option, the line rectifying circuit is bypassed and the battery voltage provides the supply for the d.c./d.c. converter. 1R6 permits the oscilloscope to be operated from either a positive or negative-ground battery supply, the voltage at pin 3 and pin 2 being 0 V and approximately -18 V respectively for a positive-ground supply, and approximately +18 V and 0 V for a negative-ground supply.

Calibrator (Fig. 7-3)

54. The voltage calibrator consists of an emitter-coupled astable 2VT7 and 2VT8 which oscillates at 1 kHz set by 3RV2, and an amplifier 2VT9. Potential divider 2R34 to 2R37 ensures that as 2VT9 is switched between its fully-conducting and non-conducting states accurate voltage outputs of 1 V and 100 mV are provided at SKTA and SKTB respectively.

C.R.T. Circuit (Fig. 7-2)

55. RV12 (FOCUS) is positioned approximately centrally in a potential divider connected between 0 V and -1.35 kV, the voltage at its wiper being applied to the c.r.t. focusing anode. This control is adjusted in conjunction with RV14(ASTIG) to achieve optimum beam spot size on the screen. The c.r.t. total beam current is set by RV13 (BRILL), and D4 acts as a constant-voltage supply, maintaining the voltage across RV13, and thus across RV12, for different settings of RV13.

56. Pin-cushion or barrel distortion is minimised by 2RV9 (geometry adjust).

57. The c.r.t. heater is powered from an a.c. supply derived from a seperate winding on 1T1. This supply is referenced to the negative e.h.t. supply at the c.r.t.

58. RV16 (TRACE ROTATE) determines the amplitude and direction of the current in L1 and so permits the c.r.t. trace to be aligned with the graticule.

SECTION 3 - CALIBRATION

INTRODUCTION

1. The procedures in this section refer to the adjustment of internal or front-panel preset controls. Control settings and test equipment connections should not be changed except as instructed. Details of periodic performance checks are to be found in Section 5.

2. Where procedures are identical for channels 1 and 2, channel 2 component references (or control annotations, etc.) are quoted in brackets, immediately following the channel 1 component references.

3. Reference should be made to Section 2, Paras. 1 and 2, for the system of component coding used in this manual.

PRECAUTIONS

4. Do not remove the cover unless the instrument is disconnected from the a.c. supply (or battery, if d.c. operated).

5. When the instrument is withdrawn from its case and power applied, access is immediate to dangerous voltages:

   (a) up to 250 V a.c. derived from the a.c. supply.

   (b) up to +9 kV d.c. from 1T1 (c.r.t./p.d.a. voltage).

   (c) up to -1.35 kV d.c. from 1T1 (c.r.t. cathode voltage).

TEST EQUIPMENT

6. The following test equipment is required:

   (a) A.C. and d.c. multi-range voltmeter, sensitivity 20,000 ohms per volt, calibrated against a sub-standard instrument at 20 V (an Avo model 8SX is suitable).

   (b) Oscilloscope, general purpose. Specification similar to that of the SM113.

   (c) An oscilloscope calibrator (a Bradley 156 is suitable). Set voltage output to squarewave (1 kHz).

   (d) Two constant amplitude sinewave generators. Frequency variable between 1 kHz and 50 kHz and output variable between 0 V and 10 V when loaded

with 1 MΩ (an Advance SG67 is suitable).

(e) Capacitance standardiser. 35 pF shunted by 1 MΩ ± 1%, BNC socket. A Tektronix 067-0540-00 (33 pF) is suitable when adjusted for 35 pF.

(f) A fast pulse generator providing pulses with a rise-time better than 4 ns, pulse top flat to within 1% and overshoot less than 2% (a Tektronix 106 is suitable).

(g) Termination pad (50 ohms resistance pad).

PRELIMINARY SETTINGS

7. (a) Remove the cover from the instrument (four 6-32 UNC screws on rear panel), and the protective cover from the power unit board.

(b) Ensure that the input voltage selector is set to the 230 V position and that fuse links FS1 (500 mA) and FS2 (2A) are correctly positioned and in good order.

(c) Connect the oscilloscope to a 230 V a.c. supply.

(d) Set: (i) BRILL fully counter-clockwise

(ii) TRIG MODE to AUTO; TRIG SOURCE to CH1; slope to +

(iii) TIME/cm to 0.1 ms/cm; TIME/cm VAR to CAL; EXPAND to x1;

(iv) MODE to CH1

(v) CH1 V/cm to 0.5 V/cm; V/cm FINE to CAL; GAIN to x1; AC

(vi) CH2 V/cm to 0.02 V/cm; V/cm FINE to CAL; GAIN to x1; GND

(vii) PULL TO INVERT pushed in.

(e) Set SUPPLY downwards (on). Check that the SUPPLY lamp glows and allow the oscilloscope five minutes to stabilise.

POWER SUPPLIES

8. (a) Connect the test meter, set to the 25 V d.c. range, between pin 6(+ve) and pin 3 or pin 8(ground-chassis) on TB1.

(b) Adjust 1R13 to obtain an indication of 20 V ± 0.05 V.

C.R.T. GEOMETRY

9. (a) Connect the test constant-amplitude sinewave generator, frequency set to 50 kHz, output approximately 2 V peak-to-peak, to CH1 IN.

(b) Advance BRILL until the intensity of the trace is adequate and adjust FOCUS and ASTIG to obtain a well-defined trace.

NOTES: 1. To increase the life of the c.r.t. do not turn BRILL higher than necessary for a satisfactory display.

2. To check for correct setting of the ASTIG control, slowly turn FOCUS through the optimum setting. If the ASTIG adjustment is correct, the horizontal and vertical portions of of the channel 1 trace will come into sharpest focus at one position of the FOCUS control. The setting of the ASTIG control should then be correct for any display.

(c) Adjust the CH1 SHIFT to position the display about the central horizontal graticule line. If necessary, adjust TRACE ROTATE to set the display parallel with the horizontal graticule lines.

(d) Set the OUTPUT of the test sinewave generator to produce a display of 8 cm amplitude.

(e) Connect the other test sinewave generator, frequency set to 1 kHz to X IN. Set TIME/cm switch to X IN DC. Set the output of the sinewave generator to produce a display of width 10 cm. Adjust X SHIFT as necessary.

(f) Adjust geometry adjust, 2RV9, so that the raster is as near rectangular as possible. Ensure that each horizontal edge lies within a pair of imaginary lines 1.0 mm apart drawn along the edges of the graticule, and each vertical edge lies within a pair of imaginary lines 1.25 mm apart drawn along the edges of the graticule.

NOTE: As 2RV9 is adjusted, the sensitivity of the c.r.t. will alter. The output of the signal generators will therefore require resetting during this adjustment procedure.

(g) Disconnect the signal generators and reset the TIME/cm switch to an internal sweep position.

C.R.T. MODULATION

10. (a) Set TIME/cm switch to X IN DC.

(b) Connect the test meter between 2TP11 (+ve) and a convenient 0 V point (-ve).

(c) Adjust 2RV1 to obtain an indication of +9 V ± 2 V.

(d) Disconnect the test meter and reset TIME/cm switch to an internal sweep position.

CHANNEL 1 (CHANNEL 2) GAIN

D.C. Conditions

11. (a) Set: (i) MODE to CH1 (CH2)

(ii) SHIFT, 5RV1(6RV1), to centre of travel.

(iii) V/cm, 5SA(6SA), to 0.02 V/cm FINE, RV8(RV10), to CAL; GAIN, SJ(SK), to x1; GND.

(iv) BAL, RV6(RV7), to centre of travel.

(b) Connect the test meter, set to the 25 V d.c. range, between 4TP4 and 4TP5. Adjust coarse balance, 3RV3(3RV6) for an indication on the meter of 0 V ± 10 V. Disconnect the meter.

(c) Adjust BAL, RV6(RV7), so that on switching GAIN, SJ(SK) between the x1 and x10 positions any vertical movement of the trace is less than 2 mm.

(d) If necessary, adjust SHIFT, 5RV1(6RV1), to position the trace on the central horizontal graticule.

(e) Connect the test meter, set to the 2.5 V d.c. range, between 3TP6(3TP16) and 0 V. Adjust trigger centre, 3RV7(3RV8), for an indication on the meter of 0 V.

x1 Gain

12. (a) Set: (i) CH1 (CH2) input coupling to AC.

(ii) TIME/cm to 1 ms/cm; TIME/cm VAR to CAL; EXPAND to x1.

(b) Connect the voltage output of the test oscilloscope calibrator, output amplitude 120 mV, to CH1 IN (CH2 IN).

(c) Centralise the display (this may or may not be synchronised) with SHIFT, 5RV1(6RV1), if necessary. Set the amplitude of the display to 6 cm with SET CAL, RV9(RV11).

x10 Gain

13. (a) Reduce the output of the test oscilloscope to 12 mV peak-to-peak.

(b) Set GAIN, SJ(SK), to x10 and set the amplitude of the display to 6 cm with set x10 gain, 3RV2(3RV5).

(c) Reset GAIN, SJ(SK), to X1 and disconnect the test oscilloscope calibrator.

Set Leakage

14. (a) Set: (i) MODE to CH1 (CH2)

(ii) CH1 (CH2) input coupling to GND.

(iii) SHIFT, 5RV1(6RV1), to centralise trace on screen.

(b) Note any change in the vertical position of the trace when the input coupling is switched from GND to DC. Adjust set leakage, 3RV1(3RV4), to reduce the change to less than 0.5 mm.

TRIGGER

15. (a) Set: (i) TRIG SOURCE to EXT.

(ii) TRIG MODE to AUTO.

(b) Connect the test meter, set to the 2.5 V d.c. range, between 2 TP1 and 0 V. Adjust external trigger centre, 2RV8 for an indication on the meter of 0 V ± 0.2 V.

NOTE: It may be necessary to connect 2LK1 across 2D12 or, if already connected, remove 2LK1 from 2D12 to achieve this condition.

HORIZONTAL DEFLECTION SYSTEM

x1 Gain and Sweep Length

16. (a) Set: (i) MODE to CH1.

(ii) CH1 V/cm FINE to CAL; GAIN to x1; AC.

(iii) TRIG MODE to AC; SLOPE to +; TRIG SOURCE to CH1.

(iv) TIME/cm to 1 ms/cm; TIME/cm VAR to CAL; EXPAND to x1.

(b) Connect the time output of the test oscillscope calibrator, output period 1 ms, to CH1 IN. Set CH1 V/cm for a display amplitude of approximately 2 cm. If necessary, adjust LEVEL to obtain a stable display.

(c) Position the first marker (start of trace) on the left-hand vertical graticule line with X SHIFT. Adjust set x1, gain 2RV5, so that the markers are 1 cm apart and the second and tenth are aligned with the first and ninth vertical graticule lines from the left.

(d) Position the second marker on the left-hand vertical graticule line with X SHIFT. Adjust set trace length, 2RV3, so that the trace just extends to the right-hand vertical graticule line (i.e. overall trace length of 11 cm).

x5 Gain

17. (a) Set EXPAND to x5 and position the first marker on the left-hand vertical graticule line with X SHIFT. Adjust set x5 gain, 2RV7, so that the markers are 5 cm apart, i.e. the second and third align with the centre and right-hand vertical graticule lines, respectively.

(b) Reset EXPAND to x1.

Sweep Calibration

18. (a) Set: (i) TIME/cm to 20 ms/cm.

(ii) Oscilloscope calibrator output period to 20 ms.

(b) If necessary position the first marker (start of trace) on the left-hand vertical graticule line with X SHIFT. Adjust sweep control, 2RV4, so that the markers occur one per centimetre.

(c) Set: (i) TIME/cm to 0.1 ms/cm

(ii) Oscilloscope calibrator output period to 0.1 ms.

(d) If necessary, position the first marker (start of trace) on the left-hand vertical graticule line with X SHIFT. Adjust set sweep control, 2RV6, so that the markers occur one per centimetre.

(e) Set: (i) TIME/cm to 0.5 μs/cm

(ii) Oscilloscope calibrator output period to 0.5 μs.

(f) If necessary, position the first marker (start of trace) on the left-hand vertical graticule line with X SHIFT. Adjust sweep control, 2RV5, so that the markers occur one per centimetre.

(g) Disconnect the test oscilloscope calibrator.

NOTE: On the faster sweep ranges it may become necessary to adjust HF SYNC to obtain a stable display.

CALIBRATOR

19. (a) Set: (i) TIME/cm to 0.1 ms/cm; TIME/cm VAR to CAL; EXPAND to x1.

(ii) MODE to ALT.

(iii) TRIG MODE to AUTO; TRIG SOURCE to CH1; SLOPE +.

(iv) CH2 V/cm to 0.05 V/cm.

(v) CH1 and CH2 V/cm FINE to CAL; GAIN to x1; AC.

(b) Connect the test oscilloscope calibrator, output period 1 ms (1 kHz), to CH1 IN. Set CH1 V/cm for display amplitude approximately 2 cm. If necessary adjust LEVEL for a stable display.

(c) Connect 100 mV 1 kHz calibrator output to CH2 IN.

(d) Adjust 2RV2 so that the drift rate of the CH2 trace is less than one cycle per second, i.e. the time for a pulse on the CH2 trace to drift between any two markers on the CH1 trace is less than one second.

(e) Disconnect the test oscilloscope calibrator and the 100 mV 1 kHz calibrator output.

CHANNEL 1 (CHANNEL 2) RESPONSE

Input Capacitance

20. (a) Set: (i) TIME/cm to 1 ms/cm; TIME/cm VAR to CAL; EXPAND to x1.

(ii) MODE to CH1 (CH2).

(iii) V/cm to 0.02 V/cm; V/cm FINE to CAL; GAIN to x1; AC.

(iv) TRIG MODE to AUTO; TRIG SOURCE to CH1(CH2);SLOPE +.

(b) Connect the voltage output of the test oscilloscope calibrator output amplitude 250 mV peak-to-peak, via the (35 pF) capacitance standardiser to CH1 IN (CH2 IN).

(c) Adjust 3C1 (3C15) so that any undershoot or overshoot on the displayed waveform is less than 1%

Attenuator Settings

21. (a) Reconnect the test oscilloscope calibrator, output amplitude set to 250 mV, directly to CH1 IN (CH2 IN). Set V/cm to 0.05 V/cm.

(b) Check that the amplitude of the displayed waveform is 5 cm ± 1 mm and adjust 5C15 (6C15) so that any undershoot or overshoot on the waveform is less than 1%.

(c) Repeat this adjustment for the appropriate capacitor selected by the V/cm switch as detailed in Table 3-1, resetting the output of the oscilloscope calibrator as indicated.

V/cm setting 5SA (6SA)	Oscilloscope calibrator output	Channel 1 adjust	Channel 2 adjust
0.1	250 mV	5C18	6C18
0.2	500 mV	5C3	6C3
0.5	1 V	5C13	6C13
1	5 V	5C16	6C16
2	10 V	5C7	6C7
20	100 V	5C11	6C11

TABLE 3-1 ATTENUATOR COMPENSATION

(d) Reconnect the capacitance standardiser between the oscilloscope calibrator and CH1 IN (CH2 IN).

(e) Set the V/cm switch and the output of the oscilloscope calibrator as detailed in Table 3-2 and adjust the appropriate capacitor so that any undershoot or overshoot on the displayed waveform is less than 1%. Adjust SHIFT, 5RV1 (6RV1) as necessary.

V3cm setting 5SA (6SA)	Oscilloscope calibrator output	Channel 1 adjust	Channel 2 adjust
0.2	2 V	5C2	6C2
2	20 V	5C6	6C6
20	200 V	5C10	6C10

TABLE 3-2 ATTENUATOR INPUT CAPACITY

(f) Disconnect the capacitance standardiser and oscilloscope calibrator.

Pulse Response

22. (a) Set: (i) V/cm to 0.02 V/cm; V/cm FINE to CAL; GAIN to x1; AC.

(ii) MODE to CH1 (CH2)

(iii) TIME/cm to 2 μs/cm; TIME/cm VAR to CAL; EXPAND to x1.

(iv) TRIG MODE to AC; SLOPE to +; TRIG SOURCE to CH1 (CH2).

(b) Connect the positive edge output of the fast pulse generator p.r.f. set to 100 kHz; via termination pad, to CH1 IN (CH2 IN).

(c) Adjust LEVEL, the generator output amplitude and SHIFT to obtain a stable display, approximately 5 cm in amplitude, positioned about the centre of the graticule, the whole of the positive edge being visible and starting at approximately 0.3 cm from the start of the trace.

(d) Adjust 3C6 (3C20), 3C10 (3C24) and 4C2 so that any overshoot on the waveform is less than 2.5% and any ring is less than 1.5%.

NOTE: To obtain optimum pulse response between Channel 1 and Channel 2, it may be necessary to set 4C2 at a compromise adjustment.

(e) Disconnect the termination pad and fast pulse generator.

SECTION 4 - TROUBLESHOOTING

GENERAL

1. The following information is provided to facilitate fault diagnosis of the SM113. Reference should be made to other sections of this handbook, in conjunction with this section, to aid in locating the defective component(s): the circuit descriptions, circuit diagrams and component location diagrams are specially helpful in this respect. Reference should be made to Section 2, Sub-section 1, for the method of component coding used.

PRECAUTIONS

2. Do not remove the cover unless the instrument is disconnected from the a.c. supply (or battery, if d.c. operated).

3. When the instrument is withdrawn from its case and power applied, access is immediate to dangerous voltages:

   (a) 250 V a.c. supply.

   (b) +9 kV d.c. from 1T1 (c.r.t./p.d.a. voltage).

   (c) -1.35 kV d.c. from 1T1 (c.r.t. cathode voltage).

WIRING COLOUR CODE

4. All insulated wires and cables used in the oscilloscope are colour-coded to aid circuit tracing. Signal-carrying leads are single coloured and with exception of co-axial and twin-feeder leads, are type 7/0076. The low-voltage supply leads (i.e. not e.h.t. leads) are single coloured, with the exception of the -40 V line, and are type 14/0076. Table 4-1 gives the wiring colour code for the low-voltage supply leads.

Supply	Colour	Supply	Colour
+125 V	Brown	0 V	Black
+75 V	Red	-9 V	Slate
+20 V	Orange	-40 V	Red/Yellow
+9 V	Yellow		

TABLE 4-1 POWER SUPPLY WIRING COLOUR CODE

FAULT FINDING EQUIPMENT

5. The following test equipment is useful in locating faults:

(a) Multimeter. A.C. and d.c. multi-range voltmeter, sensitivity 20,000 ohms per volt, ohmmeter 0 to 20 megohms. Multimeter Avo Model 8SX is suitable.

(b) Test oscilloscope. An oscilloscope of specification similar to that of the SM113. A probe should be used to reduce circuit loading.

(c) Transistor tester.

FAULT DIAGNOSIS TECHNIQUES

6. Before proceeding with the detailed guides to fault location shown in Section 7, Fig. 7-7 to 7-11 inclusive, the following simple checks should be made:

(a) Control settings. Ensure that the controls are correctly set: in many cases, apparent faults are due to incorrect settings.

(b) Calibration. Many apparent faults may be due to misalignment: these can be corrected by following the relevant procedures in Section 3.

(c) Fault location. To isolate a fault to circuit level, note any symptoms. In many cases, the circuit or board in which the fault has occurred can be identified from those symptoms. For example, an unacceptable quality of display (e.g. excess brilliance, poor focus) indicates that the c.r.t. or relevant display controls, or e.h.t. may be faulty. Incorrect operation of many (or all) circuits indicates a fault in the power supply or supply interconnections. Note that a fault on one supply may cause all the outputs of the d.c./d.c. converter to fail. A large overload will cause a protective fuse to rupture.

(d) Overheated components. Failure of a component due to overheating may be a sympton of a fault in an associated circuit. After replacing such a component, check whether overheating and failure recurs. If so, determine the cause.

7. The fault location charts provide guides in locating faults, in many instances down to component level. However, the charts can only cover typical faults and omit faults that are obvious in location (e.g. no difference in display between

the x1 and x5 positions of the EXPAND switch indicates that the X-amplifier circuit is faulty).

8. Figure 7-7 is a master fault location chart and should be the first to be used. It locates the fault down to board level and refers the serviceman to the appropriate fault location chart. However, the location of faults may be immediately obvious from symptoms noted when calibration procedures or performance checks have been made. Direct reference should then be made to the appropriate chart. However, to maintain a logical development on all charts, some duplication of information exists between charts.

NOTE: Renewal of components or repair may necessitate recalibration of the affected circuits.

SECTION 5 - MAINTENANCE

INTRODUCTION

1. This section contains information on preventive maintenance, performance checks and renewal of sub-assemblies. The performance checks which can be made without the cover being removed from the instrument, may be used to provide symptoms of fault conditions (see Section 4) and supplement the calibration procedures detailed in Section 3. Front-panel preset controls are adjusted in this procedure.

2. Reference should be made to Section 2, Paras. 1 and 2 for the system of component coding used in this manual.

NOTE: Assistance in Servicing can be obtained from the Service Dept., S.E. LABORATORIES(Engineering)LTD. Tel. No. 01-890-1166.

PRECAUTIONS

3. Do not remove the cover unless the instrument is disconnected from the a.c. supply (or battery,if d.c. operated). When the instrument is withdrawn from its case and power applied, access is immediate to dangerous voltages:

(a) 250 V a.c. derived from the a.c. supply.

(b) +9 kV d.c. from 1T1(c.r.t./p.d.a. voltage)

(c) -1.35 V d.c. from 1T1 (c.r.t. cathode voltage).

PREVENTIVE MAINTENANCE

4. This includes cleaning, visual inspection and lubrication and if performed periodically, may prevent breakdown. The frequency of maintenance is determined by the environment to which the oscilloscope is subjected: a convenient time is preceding recalibration.

Cleaning

5. Dust accumulation within the oscilloscope, due to its heat-insulating effect on components, can cause reduced heat dissipation and thus breakdown. In conditions of high humidity its electrical conductivity increases, so that high-voltage may occur on or around components associated with the two e.h.t. supplies.

6. A dry, low-velocity air line is recommended for removing dust, a small brush being particularly useful for dislodging dirt in inaccessible places such as switch wafers and on or under front-panel controls.

Visual Inspection

7. Periodically inspect the oscilloscope for mechanical defects (e.g. on rotary switches or support brackets), for broken connections, including the printed wiring on the circuit boards, and for evidence of overheated components.

8. The occasional use of an approved lubricant (one that does not affect electrical or mechanical characteristics) can help to maintain the reliability of moving parts (e.g. rotary switches and potentiometers). Do not overlubricate. Panclimatic grease should be used to lubricate concentric shafts.

PERFORMANCE CHECKS

9. These checks refer to the adjustment of front panel controls (including preset controls). During the tests, control setting or test equipment connections should not be changed except as instructed.

10. Where checks are identical for channels 1 and 2, channel 2 component references (or control annotations, etc.) are quoted in brackets, immediately following the channel 1 component reference.

TEST EQUIPMENT

11. The following test equipment is required to carry out the performance checks:

(a) An oscilloscope calibrator. (Bradley 156 is suitable). Except where stated, the voltage output is set to squarewave (1 kHz).

(b) A low-frequency sinewave generator, frequency variable between 1 kHz and 50 kHz and output variable between 0 V and 10 V when loaded with 1 MΩ. An Advance SG67 is suitable.

(c) Constant-amplitude oscillator, frequency variable between 50 kHz and 15 MHz, output variable betwwen 0 mV and 1 V. A Tektronix 191 is suitable.

(d) Oscilloscope with specification similar to the SM113.

Preliminary Settings

12. (a) Ensure that the input voltage selector is set to 230 V and that fuse links FS1 (500 mA) and FS2 (2 A) are correctly positioned and in good order.

(b) Connect the oscilloscope to a 230 V a.c. supply.

(c) Set: (i) BRILL fully counter-clockwise.

(ii) TRIG MODE to AUTO; TRIG SOURCE to CH1; SLOPE to +.

(iii) TIME/cm to 1 ms/cm; TIME/cm VAR to CAL; EXPAND to x1; INT SWEEP.

(iv) MODE to CH1.

(v) CH1 V/cm to 0.5 V/cm; V/cm FINE to CAL; GAIN to x1; AC.

(vi) CH2 V/cm to 0.02 V/cm; V/cm FINE to CAL; GAIN to x1; GND.

(vii) PULL TO INVERT pushed in.

(d) Set SUPPLY downwards (on). Check that the SUPPLY lamp glows and allow the oscilloscope five minutes to stabilise.

Cathode Ray Tube

13. (a) Connect the voltage output of the test oscilloscope calibrator, output amplitude 2 V, to CH1 IN.

(b) Advance BRILL until the intensity of the trace is adequate and adjust FOCUS and ASTIG to obtain a well-defined trace.

NOTES: 1 To increase the life of the c.r.t. do not turn BRILL higher than necessary for a satisfactory display.

2. To check for correct setting of the ASTIG control, slowly turn FOCUS through the optimum setting. If the ASTIG adjustment is correct, the horizontal and vertical portions of the channel 1 trace will come into sharpest focus at one position of the FOCUS control. The setting of the ASTIG control should then be correct for any display.

(c) Adjust CH1 SHIFT to position the display about the central horizontal graticule line. If necessary adjust TRACE ROTATE to set the display parallel with the horizontal graticule lines.

(d) Disconnect the test oscilloscope calibrator.

Channel 1 (Channel 2) Balance

14. (a) Set: (i) MODE to CH1 (CH2)

(ii) CH1 (CH2) V/cm to 0.02 V/cm; V/cm FINE to CAL; GAIN to x1; AC.

(iii) SHIFT, 5RV1 (6RV1), to centre of travel.

(iv) Other controls as detailed in Para. 12(c) (ii), (iii), (vii).

(b) Check that the range on BAL, RV6, (RV7), is such that it will position the trace anywhere within the vertical limits of the graticule.

(c) Set GAIN, SJ(SK), to x10 and check that the trace can be centred with BAL, RV6 (RV7).

(d) Adjust BAL, RV6(RV7) so that on switching GAIN, SJ(SK), between the x1 and x10 positions any vertical movement of the trace is less than 2 mm. Reset GAIN, SJ(SK), to x1.

(e) Check that the range of SHIFT, 5RV1 (6RV1), is such that it will position the trace anywhere within the vertical limits of the graticule.

Channel 1(Channel 2) Gain

15. (a) Connect the voltage outputs of the test oscillator calibrator output amplitude 120 mV, to CH1 IN (CH2 IN).

(b) Centralise the display with SHIFT, 5RV1 (6RV1). Set the amplitude of the display to 6 cm with SET CAL, RV9 (RV11).

(c) Set V/cm FINE, RV8 (RV10), fully counter-clockwise. Check that the amplitude of the display is less than 2.4 cm. Reset V/cm FINE to CAL.

(d) Set the voltage output of the calibrator to 0 mV, +, and switch CH1(CH2) input coupling to DC.

(e) Set the voltage output of the calibrator to 120 mV, +. Check that the shift in displayed level is +6.1 cm ± 0.1 cm.

(f) Set the voltage output of the calibrator to 12 mV, and GAIN, SJ(SK), to x10. Check that the amplitude of the display is 6 cm. Return GAIN x1.

Channel 1 (Channel 2) Attenuators

16. (a) Set: (i) MODE to CH1 (CH2)

(ii) TRIG MODE to AUTO: TRIG SOURCE to CH1(CH2): SLOPE to +.

(iii) CH1 (CH2) V/cm to 0.02 V/cm.

(b) Set the voltage of the test oscilloscope calibrator to 100 mV. Check that the amplitude of the displayed waveform is 5 cm ± 1 mm and that any undershoot or overshoot present on the waveform is less than 1%.

(c) Repeat this check for the appropriate settings of the V/cm switch as detailed in Table 5-1, resetting the output of the test oscilloscope calibrator as indicated.

V/cm setting 5SA (6SA)	Oscilloscope calibrator output	Display amplitude (± 1 mm)
0.05	250 mV	5 cm
0.1	500 mV	5 cm
0.2	1 V	5 cm
0.5	2.5 V	5 cm
1	5 V	5 cm
2	10 V	5 cm
5	25 V	5 cm
10	50 V	5 cm
20	100 V	5 cm
50	100 V	2 cm

TABLE 5-1 ATTENUATION RATIO CHECK

(d) Disconnect the test oscilloscope calibrator.

Vertical Mode

17. (a) Set: (i) CH1 and CH2 input coupling to GND

(ii) TIME/cm to 0.1 ms/cm

(iii) MODE to ALT.

(b) Check that alternate sweeps (one second duration) are under the control of CH1 SHIFT then CH2 SHIFT.

(c) Set MODE to CHOP. Check that two traces are visible, one under the control of CH1 SHIFT, the other under control of CH2 SHIFT.

(d) Set: (i) MODE to ALT

(ii) CH1 and CH2 V/cm to 0.02 V/cm; AC

(iii) TRIG SOURCE to CH1.

(iv) TIME/cm to 1 ms/cm.

(e) Connect the voltage output of the test oscilloscope calibrator, output amplitude 160 mV, to both CH1 IN and CH2 IN. Position both traces within the graticule with CH1 SHIFT and CH2 SHIFT.

(f) Set MODE to CH1 + 2, pull out PULL TO INVERT and adjust either CH1 or CH2 V/cm FINE to reduce the display amplitude to less than 1 mm peak.

(g) Reduce the test oscilloscope calibrator output to 80 mV and push in PULL TO INVERT. Check that the display amplitude is 8 cm ± 0.2 cm.

(h) Set CH2 input coupling to GND. Check that the display amplitude is 4 cm ± 0.1 cm.

Trigger Level

18. (a) Set: (i) TRIG SOURCE to EXT; TRIG MODE to AC; SLOPE to +.

(ii) MODE to CH1

(iii) CH1 V/cm to 1 V/cm FINE to CAL; GAIN to x1; AC.

(iv) Connect the sinewave generator, output frequency 1 kHz, and amplitude 6 V peak-to-peak to CH1 IN.

(b) Check that the start of the trace (i.e. triggering) can be adjusted by LEVEL to occur at any point on the positive-going slope of the waveform.

(c) Set SLOPE to −. Ensure that triggering can be set by LEVEL to occur at any point on the negative-going slope of the waveform.

(d) Set CH1 V/cm to 2 V/cm and TRIG MODE to AUTO. Check that the triggering point is on the negative-going slope near the centre of the waveform.

(e) Set SLOPE to +. Check that the triggering point is on the positive-going slope near the centre of the waveform.

Trigger Sensitivity and Response

19. (a) Set CH1 V/cm to 0.1 V/cm and the output of the test sinewave generator to 250 mV peak-to-peak. Check that stable triggering occurs.

(b) Set SLOPE to -. Check that stable triggering occurs.

(c) Set TRIG MODE to AC. Check that stable triggering can be obtained, adjusting LEVEL if necessary.

(d) Set SLOPE to +. Check that stable triggering can be obtained, adjusting LEVEL if necessary.

(e) Set CH1 V/cm to 2 V/cm, TRIG SOURCE to EXT ÷ 20, and the output of the test sinewave generator to 5 V peak-to-peak. Check that stable triggering can be obtained, adjusting LEVEL if necessary. Disconnect the test sinewave generator and connect the test constant-amplitude oscillator to CH1 IN.

(f) Set: (i) TRIG SOURCE to EXT.

(ii) TIME/cm to 0.2 μs/cm.

(g) Set the output of the test constant-amplitude oscillator to 250 mV and the frequency to 5 MHz. Check that stable triggering can be obtained, adjusting LEVEL and HF SYNC as necessary.

(h) Set the output of the test constant-amplitude oscillator to 500 mV and the frequency to 15 MHz. Check that stable triggering can be obtained, adjusting LEVEL and HF SYNC as necessary. Disconnect the test constant-amplitude oscillator.

Trigger Source

20. (a) Set: (i) TRIG SOURCE to CH1 (CH2); TRIG MODE to AUTO; SLOPE to +.

(ii) MODE to CH1 (CH2).

(iii) TIME/cm to 1 ms/cm.

(iv) CH1 (CH2) V/cm to 0.02 V/cm; AC.

(b) Connect the test sinewave generator, amplitude set to 36 mV, to CH1 IN (CH2 IN), i.e signal amplitude of 1.8 cm. Set CH1 (CH2) V/cm to 0.2 V/cm and check that stable triggering can be obtained with SLOPE set to + and then to -.

(c) Set TRIG MODE to AC and check that stable triggering can be obtained on either position of the SLOPE switch, adjusting LEVEL if necessary.

(d) Set MODE to CHOP and check that stable triggering can be obtained. Disconnect the test sinewave generator.

Horizontal Gain and Sweep Length

21. (a) Set: (i) MODE to CH1.

(ii) CH1 V/cm FINE to CAL; GAIN to x1; AC.

(iii) TRIG MODE to AC; SLOPE to +; TRIG SOURCE to CH1.

(iv) TIME/cm to 1 ms/cm; TIME/cm VAR to CAL; EXPAND to x1.

(b) Connect the time output of the test oscilloscope calibrator, output period 1 ms, to CH1 IN. Set CH1 V/cm for a display amplitude of approximately 2 cm. If necessary, adjust LEVEL to obtain a stable display.

(c) Position the first marker (start of trace) on the left-hand graticule line with X SHIFT. Check that the markers are 1 cm apart and that the second and tenth are aligned with the first and ninth vertical graticule lines from the left.

(d) Set TIME/cm VAR fully counter-clockwise. Check that the number of markers per cm increases to not less than $2\frac{1}{2}$. Reset TIME/cm VAR to CAL.

(e) Check that the overall trace length is approximately 11 cm and that the start of the trace can be positioned anywhere within the horizontal limits of the graticule with X SHIFT.

(f) Set EXPAND to x5 and position the first marker on the left-hand vertical graticule line with X SHIFT. Check that the markers are 5 cm apart i.e. the second and third align with the centre and right-hand vertical graticule lines, respectively. Reset EXPAND to x1.

Sweep Rate

22. (a) Set TIME/cm and the output period of the test oscilloscope calibrator as detailed in Table 5-2. Check that the number of markers displayed per cm are as indicated, to a tolerance of ± 2%.

TIME/cm setting	Oscilloscope calibrator output period	No. of markers per cm
1 s	0.5 s	2
0.5 s	0.5 s	1
0.2 s	0.2 s	1
0.1 s	0.1 s	1
50 ms	50 ms	1
20 ms	20 ms	1
10 ms	10 ms	1
5 ms	5 ms	1
2 ms	2 ms	1
1 ms	1 ms	1
0.5 ms	0.5 ms	1
0.2 ms	0.2 ms	1
0.1 ms	0.1 ms	1
50 µs	50 µs	1
20 µs	20 µs	1
10 µs	10 µs	1
5 µs	5 µs	1
2 µs	2 µs	1
1 µs	1 µs	1
0.5 µs	0.5 µs	1
0.2 µs	0.2 µs	1

TABLE 5-2 SWEEP CALIBRATION CHECK

Sweep Out

23. (a) Connect the test oscilloscope to SWEEP OUT. Check that the observed waveform is sawtooth in form, rising by approximately 8 V from a level of approximately +2 V.

(b) Disconnect the test oscilloscope.

X Amplifier

24. (a) Set EXPAND to x1 and TIME/cm switch to X IN DC.

(b) Connect the test constant-amplitude oscillator, frequency set to 50 kHz, to X IN. Set the output of the oscillator, frequency set to 50 kHz, to X IN. Set the output of the oscillator to give a display amplitude of 5 cm.

(c) Increase the frequency until the display amplitude has fallen to 3.6 cm. Check that this frequency is greater than 1.9 MHz. Disconnect the test constant-amplitude oscillator.

(d) Set TIME/cm switch to X IN DC.

(e) Connect the voltage output of the test oscilloscope calibrator, output set to 5 V, to X IN. Adjust X SHIFT, if necessary, to obtain two dots approximately 5 cm apart.

(f) Set the test oscilloscope calibrator output to +. Check that the left-hand spot disappears, the right-hand spot remaining visible.

(g) Disconnect the test oscilloscope calibrator and reset TIME/cm switch to INT SWEEP.

POWER SUPPLY

25. These checks should be made after the power supply unit has been repaired.

Test Equipment

26. The following test equipment and supplies are required:

(a) A.C. and d.c. multi-range voltmeter, sensitivity 20,000 ohms per volt, calibrated against a sub-standard instrument at 20 V (an Avo model 8SX is suitable).

(b) A variac transformer. Input voltage 230 V, 50 Hz; output voltage range 80 V to 270 V, 100 VA.

(c) Electrostatic voltmeter calibrated at 3 kV (or a voltmeter capable of measuring this voltage, the meter current not being greater than 20 μA. The multimeter fitted with a suitable range extender may be used).

(d) Stabilised d.c. power supply, output voltage variable between 20 V and 30 V, maximum output current 1.5 A.

Procedure

27. (a) Ensure that the input voltage selector is set to the 230 V position and that fuse links FS1 (500 mA) and FS2 (2A) are correctly positioned and in good order.

(b) Connect the oscilloscope to the output of the test variac and connect the variac, output set to a minimum, to a 230 V a.c. supply. Increase the variac output to 230 V.

(c) Set BRILL fully counter-clockwise and SUPPLY downwards (on). Check that the SUPPLY lamp glows and allow the oscilloscope five minutes to stabilise.

(d) Connect the test meter, set to the 25 V d.c. range, between TB1-6 (+ve) and TB1-3 or TB1-8 (ground). Adjust 1RV1 to obtain an indication of 20 V ± 0.05 V.

(e) Check that the voltage of each supply, with respect to ground (TB1-3 or TB1-8) is within the specified limits (Table 5-3).

Supply line (nominal)	Pin No.	Meter indication and tolerance
+125 V	TB1-9	+125 V ± 5 V
+75 V	TB1-7	+75 V ± 3 V
+75 V	TB1-2	
+20 V	TB1-6	+20 V ± 0.05 V
+9 V	TB1-5	+9.3 V ± 0.2 V
-9 V	TB1-4	-9.6 V ± 0.2 V
-40 V	TB1-10	-42 V ± 1.5 V

TABLE 5-3 POWER SUPPLY MONITORING

NOTES: 1. Before connecting (or disconnecting) the relevant test meter to the pins detailed in (f), (g) and (h), following, set SUPPLY OFF.

2. X1 pin 27 and pin 28 are at a potential of -1 kV with respect to ground.

(f) Connect the electrostatic voltmeter (or the meter fitted with a shunt), set to the 2.5 kV range, between X1 pin 32 (-ve) and ground. Check that the indication on the meter is 1.35 kV ± 50 V.

(g) Connect the test meter, set to the 10 V a.c. range, between X1 pin 27 and pin 28. Check that the indication on the meter is 6.9 V ± 0.3 V.

(h) Connect the test meter between pin 31 (+ve) and ground. Check that the indication on the meter is 9 kV ± 200 V.

(j) Reconnect the test meter, set to the 25 V d.c. range, between TB1-6(+ve) and TB1-3 or TB1-8(ground). Adjust the variac to vary the line supply to the oscilloscope between 185 V and 265 V and note any variation in the +20 V supply. This variation should not be greater than 100 mV.

(k) Set SUPPLY to OFF and the variac output to 110 V. Switch the input voltage selector to 115 V and replace fuse link FS1 with a 1A fuse. Set SUPPLY downwards (on).

(m) Adjust the test variac to vary the line supply between 97 V and 133 V and note any variation in the +20 V supply. This variation should not be greater than 100 mV.

(n) Set SUPPLY to OFF and the variac output to minimum. Disconnect the test variac output to minimum. Disconnect the test variac from the 230 V a.c. supply and the oscilloscope from the variac. Reset the input voltage selector to 230 V and refit FS1 with a 500 mA fuse.

(p) Connect the test d.c. power supply to the battery input SKT H in series with the test meter, set to the 10 A d.c. range. Ensure correct polarity of connection.

(q) Set the supply to 24 V and set SUPPLY downwards (on). Check that the current is between 0.8 A and 1.4 A. Set SUPPLY to OFF.

(r) Connect the test meter, set to 25 V d.c. range, between TB1-6(+ve) and TB1-3 or TB1-8(ground). Set SUPPLY downwards (on) and vary the output of the d.c. supply between 20 V and 30 V. Check that any variation in the +20 V supply is less than 100 mV.

(s) Set SUPPLY to OFF and disconnect the test meter and d.c. supply.

RENEWAL OF SUB-ASSEMBLIES

Board Sub-Assemblies

28. Viewed from the front of the equipment, the board sub-assemblies are mounted as follows:

(a) X3, vertical amplifier. Mounted vertically on the right-hand side at the centre of the instrument. The board is hinged and can be released to gain access to components located behind it. To release the board remove the two 6BA screws that secure the support tie bar to the main-frame tie bars and the two 6BA screws that secure the board to the two ground brackets (points 6A and 6B): the board is then free to swing outwards, limited by stops on the main-frame tie bars.

(b) X4,vertical output amplifier. Mounted on the central bulkhead, at the rear of the instrument. Each side of the board is accessible, although servicing can be facilitated by swinging out board X3 and removing the four 6BA screws that secure board X4 to the central bulkhead.

(c) X2, trigger, sweep generator and X amplifier. Mounted horizontally on the left-hand side of the instrument below the c.r.t. The board is hinged and can be released to give access to the power unit. To release the board remove the 4BA screw securing the lower left-hand tie bar to the rear panel and the 6BA screw securing the tie bar to the tie-bar coupling near the front panel: the board is then free to swing outwards, limited by stops on the central bulkhead.

(d) X1 power unit. Mounted on the central bulkhead, protected by an aluminium cover, behind the trigger sweep generator and X amplifier board. The board is hinged and can be released to give access to the power-supply circuit, components mounted on the rear panel. To release the board, firstly release board X2, then remove the four screws that secure the

protective cover and unscrew the knurled thumbscrew located on the side edge of the board: the board is then free to swing outwards.

Controls

29. The controls are easily accessible, although additional access can be gained to the timebase controls by swinging out board X2, and to the vertical mode switch by swinging out board X3.

C.R.T. Renewal

30. (a) Remove the c.r.t. base protective cover from the rear panel(four 6BA screws).

(b) Remove the bezel from the front panel (two 4BA screws).

(c) Remove the c.r.t. valve-base and disconnect the p.d.a. connection.

(d) Place the instrument front panel downwards on a soft rubber pad or similar.

(e) Press firmly on the base of the c.r.t. taking care to avoid bending the pins or breaking the vacuum-seal pip, until the c.r.t. moves smoothly out of the instrument (approximately one inch).

(f) Place the instrument upright and ease the c.r.t. away from the instrument.

(g) Refit the c.r.t. by carrying out the reverse of the removal procedure, ensuring that the graticule is aligned with the front-panel sides.

Renewal of the C.R.T. Assembly

31. (a) Remove the c.r.t. base protective cover from the rear panel (four 6BA screws).

(b) Remove the bezel from the front panel (two 4BA screws).

(c) Release the c.r.t. front panel clamp (four 4BA screws).

(d) Remove the c.r.t. base, disconnect the p.d.a. connection, and unsolder the two trace-rotate leads from the c.r.t. noting the positions to which the leads were connected.

(e) Swing out board X2 and remove the cover from board X1.

(f) Remove the two self-tapping screws securing each of the two c.r.t. shield supports to the bulkhead. (Note that three of these screws are used to secure cableform cleats).

(g) Lift the rear of the c.r.t. assembly approximately $\frac{1}{2}$ in. upwards and ease it approximately 2 in. towards the rear panel. Then lift the assembly outwards and upwards clear of the main frame.

NOTE: Handle the c.r.t. assembly with care. Knocking, jarring or distortion of the shield will destroy its magnetic properties.

(h) Refit the c.r.t. assembly by carrying out the reverse of the removal procedure.

Renewal of Attenuators X5 and X6

32. (a) Remove the knobs from the V/cm/SHIFT and V/cm FINE/GAIN controls on the appropriate attenuator.

(b) Unsolder the input signal lead (white) from the barb tag at the front of the attenuator.

(c) Unsolder the leads from the BAL, CAL SET, SHIFT, V/cm FINE and GAIN controls, ground tags and barb tags on the rear of the attenuator, noting the destinations of the leads.

(d) Swing out board X3.

(e) Remove the support strut from the rear of the attenuators. This is secured by three 6BA screws, one on each attenuator and one on the PULL TO INVERT switch bracket.

(f) If removing attenuator X5 (CH1), remove the support bracket from the bulkhead and attenuator (two 6BA screws).

(g) Release the hinge brackets of board X3 from the tie bars (one 6BA screw and one 6BA stop screw on each bracket).

(h) Ease board X3 outwards and backwards to the extent of the cableform.

(j) The appropriate attenuator can then be eased out of the instrument.

(k) Refit the attenuator by carrying out the reverse of the removal procedure.

Renewal of Power Transistors, VT1 to VT3

33. The case (collector) of each of these transistors (mounted on the rear panel) is insulated from the chassis by a mica washer and insulating bushes. An insulating cover fitted over each transistor provides further insulation from ground. When

replacing one of these transistors, check the collector/chassis resistance with the multimeter before connecting the emitter and base leads. In addition, fit insulating sleeves over the emitter and base pins.

Renewal of Power Transformer, T1

34. Remove the power transformer complete with all components mounted on it, having first disconnected the leads from the cableform. Transfer the components on the old transformer on to the new one before fitting it to the instrument.

Soldering Techniques

35. Standard techniques of component renewal should be used but care must be taken to prevent excess heat from damaging the circuit board otherwise the printed wiring may lift away from the base material. When cleaning the area around a solder connection with a flux-remover solvent, be careful not to remove information printed on the board. All solder connections to components associated with either e.h.t. supply should have smooth surfaces. Any protrusions may cause high-voltage arcing in low-pressure or high-humidity environments. A vacuum-type desoldering tool is recommended for removing excess solder.

Wiring Colour Code

36. All insulated wire and cables used in the oscilloscope are colour-coded to aid circuit tracing. Signal-carrying leads are single-coloured and, with the exception of co-axial and twin-feeder leads, are type 7/0076. The low-voltage supply leads, not e.h.t. leads, are single-coloured, with the exception of the -40 line, and are type 14/0076. Table 5-4 gives the wiring colour code for the low-voltage supply leads.

Supply	Colour
+125 V	Brown
+75 V	Red
+20 V	Orange
+9 V	Yellow
0 V	Black
-9 V	Slate
-40 V	Red/Yellow

TABLE 5-4 POWER SUPPLY WIRING COLOUR CODE

SECTION 6 - PARTS LIST

1. INTRODUCTION

This section contains information for ordering replaceable parts. The tables provide the following information:

(a) Circuit Reference

(b) Value, tolerance and rating (where applicable).

(c) Manufacturer/reference

(d) S.E.L. part no.

Minor items, such as screws, nuts etc., have not been included as they are not considered special to the equipment.

2. ORDERING INFORMATION

To order your replacement part, address the order to your local agent or to S.E. LABORATORIES(ENGINEERING)LTD. SERVICE DEPARTMENT, NORTH FELTHAM TRADING ESTATE, FELTHAM, MIDDLESEX. ENGLAND. Telephone No. 01-890-1166/5876.

Specify the following information for each part:

(a) Model and serial number of the equipment.

(b) S.E.L. part number, and manufacturer's reference.

(c) Circuit reference.

(d) Description (i.e. Value, tolerance and rating).

To order a part not listed, give the part number, description of the major assembly which is listed, and a complete description of the part required.

The assemblies listed are as follows:

	TABLE
Oscilloscope SM113 Main Assembly	6-1
Power Unit X1	6-2
Trigger and Sweep Generator X2	6-3
Y Amplifier X3	6-4
Vertical Output Amplifier, X4	6-5
Attenuator, X5 and X6	6-6

TABLE 6-1 OSCILLOSCOPE SM113 MAIN ASSEMBLY

Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
		Circuit Sub-Assemblies			
X1	B62755	Power Unit			
X2	B62811	Trigger, Sweep Generator and X Amplifier			
X3	E62817	Vertical Amplifier			
X4	D62816	Vertical Output Amplifier			
X5	B62624	Attenuator (Channel 1)			
X6	B62624	Attenuator (Channel 2)			
		Capacitors (μF)			
C1	CS31303	Mullard 015/90003	4.7	+50, -10	63V
C2	CS30990	Mullard C280AE/A470K	4700	+50, -10	40V
C3	CS30954	Erie 801/K800011	0.01	-20, +80	750V
C4	CS4992	Waycom Wima MKS	0.1	20	630V
C5	Not Used				
C6	CS30167	Plessey TCC 436/1/77530/590	0.1	25	600V
C7	CS30167	Plessey TCC 436/1/77530/590	0.1	25	600V
C8	CS30175	Mullard C280AE/P10K	0.01	20	250V
C9	CS30177	Erie 831/K350081	1000p	20	500V
C10	CS30452	Erie CP5/K800011	0.03	+20, -50	1.5kV
C11	CS30951	Mullard C280AE/P100K-040	0.1	20	250V
C12	Not Used				
C13	Not Used				
C14	CS30229	Mullard C426AR/D200	200	+50, -10	10V
C15	CS30229	Mullard C426AR/D200	200	+50, -10	10V
		Diodes			
D1	Not Used				
D2	BS2242	Texas IN4003			
D3	BS2242	Texas IN4003			
D4	BS2951	Texas IS3091			

Table 6-1 (Cont'd.)

Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
		Resistors (Fixed) (Ω)			
R1	DS6248	Dubilier BTT	1 M	10	½W
R2	DS33794	Mullard MR25	47 k	2	½W
R3	DS6192	Dubilier BTT	470 k	10	½W
R4	DS33592	Mullard MR30	100 k	2	½W
R5	DS32373	Electrosil TR5 or Mullard MR25	39 k	2	½W
R6	DS32359	Electrosil TR5 or Welwyn MR5	4.7 k	2	½W
R7	DS33770	Mullard MR25	4.7 k	2	½W
R8	DS33923	Welwyn 4034/G 150 ppm/°C	2.43 M	1	-
R9	DS33922	Welwyn 4034/G 150 ppm/°C	1.21 M	1	-
R10	DS33921	Mullard MR30 150 ppm/°C	487 k	1	-
R11	DS33920	Mullard MR30 150 ppm/°C	243 k	1	-
R12	DS33919	Mullard MR30 150 ppm/°C	121 k	1	-
R13	DS33918	Mullard MR30	48.7 k	1	-
R14	DS6248	Dubilier BTT	1 M	10	½W
R15	DS6248	Dubilier BTT	1 M	10	½W
R16	DS6192	Dubilier BTT	470 k	10	½W
R17	Not Used				
R18	Not Used				
R19	Not Used				
R20	Not Used				
R21	Not Used				
R22	DS7479	Electrosil TR5 or Welwyn MR5	1 k	2	½W
R23	DS32361	Electrosil TR5 or Welwyn MR5	100	2	½W
R24	DS32361	Electrosil TR5 or Welwyn MR5	100	2	½W
		Resistors (Variable) (Ω)			
RV+SD	DS62654	AB Electronics (Linear 45)	4.7 k	20	-
RV2+SH	D62617	AB Electronics (Linear 5VA-45)	4.7 k	20	-
RV3+SC	D62655	AB Electronics (Linear 45)	4.7 k	20	-
RV4+SG	C62765/01	Pot. and concentric switch (AB Electronics Ltd)	4.7 k	20	-

Table 6-1 (Cont'd.)

Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
RV5	DS33887	Erie 83 Linear	2.2 k	20	-
RV6	FS10360	Plessey Type M Linear	4.7 k	20	-
RV7	FS10360	Plessey Type M Linear	4.7 k	20	-
RV8+SJ	C60337/01	AB Electronics Ltd., Inverse log	470	20	-
RV9	FS10362	Plessey Type M Linear	100	20	-
RV10+SK	C60337/01	AB Electronics Ltd., Inverse log	470	20	-
RV11	FS10362	Plessey Type M Linear	1 k	20	-
RV12	FS10337	S.E.L. C60263/02 Linear (AB Electronics Ltd)	1 M	20	-
RV13	FS10337	S.E.L. C60263/02 Linear (AB Electronics Ltd)	1 M	20	-
RV14	DS33888	AB Electronics Ltd., Type 45	220 k	20	-
RV15	Not Used				
RV16	FS10363	Colvern CLR1189/9S/5K	5 k	-	-
		Transistors			
VT1	BS2920	Texas TIP3055			
VT2	BS2920	Texas TIP3055			
VT3	BS2920	Texas TIP3055			
		Cathode Ray Tube (and Assemblies)			
V1	WS28763	MO Valve Co 1474G			
-	B60236	Tube and screen assembly			
-	B60235	Tube screen (includes L1)			
		Miscellaneous			
DL1	D62639	Delay Line, 180 ns			
FS1	RS23055	Fuse holder Belling Lee E6011			
FS1	RS23084	Fuse link 500 mA Beswick TDC123			
FS2	RS23055	Fuse holder Belling Lee E6011			
FS2	RS23093	Fuse link 2A Beswick TDC123			
ILP1	JS14086	Neon lamp 115V Arcoelectric			
		Switches SL162 Red			

Table 6-1 (Cont'd.)

Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
L1		Coil (Part of tube screen)			
L2	ES8407	Painton Choke 58-10-0017-10	100μH		
PLA	AS0289	Plug 3 pin Bulgin P429	Pair: Bulgin P360/SE		
-	AS1403	Socket 3 pin for PLA Bulgin P430/SE			
SKTA	AS1439	Socket (black) Belling Lee L1413			
SKTB	AS1439	Socket (black) Belling Lee L1413			
SKTC	AS1439	Socket (black) Belling Lee L1413			
SKTD	AS1469	Socket Greenpar GE35026 or			
	AS1465	Radiall Ltd. UG1094 B/U			
SKTE	AS1465	Radiall Ltd. UG1094 B/U			
SKTF	AS1465	Radiall Ltd. UG1094 B/U			
SKTG	AS1465	Radiall Ltd. UG1094 B/U			
SKTH	AS1461	Socket 3 pin Bulgin SA2404	Pair: Bulgin P561		
-	AS0504	Plug 3 pin for SKTH Bulgin SA2403			
-	AS0450	Plug 50 Ω Greenpar 35070 C12			
SA	QS22237	Switch, 3p 2w Fujisoku MST305D			
SE	D62427	Slider switch 2p 2w Aerial Pressings RA2302			
SL	QS22188	Slider switch, 2p 2w Aerial Pressings Type RA 2302			
SM	QS22240	Rotary switch, 4p 5w S.E.L. D60267			
SN	D60289	Lever switch 1p, 3w			
SP	D60289	Lever switch 1p, 3w			
TMLA	AS1462	Terminal (ground) Belling Lee L1568/E			
T1	D62638	Transformer, power			

TABLE 6-2 POWER UNIT, X1

Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
		Capacitors (fixed) (μF)			
C1	CS30951	Mullard C280AE/P100K-040	0.1	20	250V
C2	CS31025	Mullard C280AE/P220K-060	0.22	20	250V
C3		Mullard C437CB/F400	400	+50,-10	25V
C4	CS30176	Mullard C426AR/E10	10	+50,-10	16V
C5	CS31025	Mullard C280AE/P220K-060	0.22	20	250V
C6	CS30184	Mullard C437AR/E400	400	+50,-10	16V
C7	CS30184	Mullard C437AR/E400	400	+50,-10	16V
C8	CS30184	Mullard C437AR/E400	400	+50,-10	16V
C9	CS31016	Erie CD7/K35001	1000p	+50,-20	3kV
C10	CS31016	Erie CD7/K35001	1000p	+50,-10	3kV
C11	CS31016	Erie CD7/K35001	1000p	+50,-10	3kV
C12	CS31016	Erie CD7/K35001	1000p	+50,-10	3kV
C13	CS31016	Erie CD7/K35001	1000p	+50,-10	3kV
C14	CS31016	Erie CD7/K35001	1000p	+50,-10	3kV
C16	CS31013	Erie CP5/K800011	0.03	+80,-20	1.5kV
C17	CS31013	Erie CP5/K800011	0.03	+80,-20	1.5kV
C18	CS30951	Mullard C280AE/P100K-040	0.1	20	250V
C19	CS31013	Erie CP5/K800011	0.03	+80,-20	1.5kV
C20	CS31013	Erie CP5/K800011	0.03	+80,-20	1.5kV
C21	CS31013	Erie CP5/K800011	0.03	+80,-20	1.5kV
C22	CS31013	Erie CP5/K800011	0.03	+80,-20	1.5kV
C23	CS31016	Erie CD7/K350011	1000p	+80,-20	3kV
C24	CS31025	Mullard C280AE/P220K-060	0.22	20	250V
C25	CS30958	Erie 831/K3500081	1000p	20	500V
C26	CS31014	Mullard C426CB/H32	32	+50,-10	64V
C27	CS31014	Mullard C426CB/H32	32	+50,-10	64V
C28	CS30091	Mullard C437AR/F160	160	+50,-10	25V
C29	CS30091	Mullard C437AR/F160	160	+50,-10	25V
C30	CS31015	Erie 21101-101-0150-AH-0161	15	+100,-20	160V
C31		Erie 21102-101-0470-AH-0101	47	+100,-20	100V
C32		Erie CD7/N750	22p	20	6kV

Table 6-2 (Cont'd.)

Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
		Diodes			
D1	BS2542	STC 1N4148			
D2	BS2542	STC 1N4148			
D3	BS2427	Texas IN4001			
D4	BS2623	Mullard BZY88/C5V6 or			
	BS2681	Texas IS2056A			
D5	BS2427	Texas IN4001			
D6	BS2947	International Rectifier 1SB05			
D10					
to					
D15	BS2948	Bourne Semtec SCM40			
D16	BS2522	Mullard BYX10			
D17	BS2522	Mullard BYX10			
D18	BS2522	Mullard BYX10			
D19	BS2522	Mullard BYX10			
D20	BS2707	Mullard BYX36/300			
D21	BS2242	Mullard or Texas IN4003			
D22	BS2242	Mullard or Texas IN4003			
D23	BS2707	Mullard BYX36/300			
		Resistors (fixed) (Ω)			
R1	DS33875	Painton MV1A	680	5	½W
R2	DS33792	Mullard MR25	39 k	2	½W
R3	DS33788	Mullard MR25	27 k	2	½W
R4	DS33742	Mullard MR25	330	2	½W
R5	DS33768	Mullard MR25	3.9 k	2	½W
R6	DS33766	Mullard MR25	3.3 k	2	½W
R7	DS33778	Mullard MR25	10 k	2	½W
R8	DS33764	Mullard MR25	2.7 k	2	½W
R9	DS33764	Mullard MR25	2.7 k	2	½W
R10	DS33722	Mullard MR25	47	2	½W
R11	DS33760	Mullard MR25	1.8 k	2	½W

Table 6-2 (Cont'd.)

Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
R12 & R17	DS33778	Mullard MR25	10 k	2	½W
R14	DS33764	Mullard MR25	2.7 k	2	½W
R15	DS33744	Mullard MR25	390	2	½W
R16	DS33760	Mullard MR25	1.8 k	2	½W
R18	DS32439	Electrosil TR5 or Mullard MR30	220 k	2	½W
R19	DS33798	Electrosil TR5 or Mullard MR30	68 k	2	½W
R20	DS33804	Mullard MR25	12.0 k	2	½W
R21	DS33772	Mullard MR25	5.6 k	2	½W
R22	DS33770	Mullard MR25	4.7 k	2	½W
R23	DS33804	Mullard MR25	120 k	2	½W
R25	DS33914	Welwyn 4037/G or 4017	9.76 MΩ	1	
R26	DS33730	Mullard MR25	100	2	½W
R27	DS33710	Mullard MR25	15	2	½W
R29	DS33774	Mullard MR25	6.8 k	2	½W
R30	DS33233	Radio-spares (12 Ω section)	12	5	
R31	DS33606	Radio-spares (87 Ω section)	87	5	
		Resistors (Variable)			
R13	FS10299	Plessey Type MP/PC Linear or Erie 80P-2	1 k	20	¼W
R24	FS10300	Plessey Type MP/PC Linear or Erie 80P-2	47 k	20	¼W
		Transistors			
VT1	BS2533	Mullard BFY51			
VT2	BS2786	Texas BC182L			
VT3-5 VT7	BS2730	Texas BC214L			
VT6	BS2561	Texas or Mullard BF178			
		Miscellaneous			
L1,L2	ES8356	H.F. Choke. Painton 58/10/0014/10	33 µH	10	
T1	D62611	Transformer			

TABLE 6-3 TRIGGER, SWEEP GENERATOR AND X AMPLIFIER, X2

Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
		Capacitors (fixed) (μF)			
C1	CS31018	Erie 831/N4700	270p	20	500V
C2	CS30954	Erie 801/K800011	0.01	+80,-20	750V
C3	CS30455	Mullard C426AR/D125	125	+50,-10	10V
C4	CS30951	Mullard C280AE/P100K-040	0.1	20	250V
C5	CS30957	Erie 831/N1500	33p	20	500V
C6	CS31018	Erie 831/N4700	270	20	500V
C7	CS31023	Erie 831/N4200	68p	20	500V
C8		Erie 831/NPO	10p	20	500V
C9	CS31020	Erie 831/N1500	47p	20	500V
C10	CS30947	Mullard C280AE/P47K-040	0.047	20	250V
C11	CS30124	ITT/PMA or Ashcroft A2B1013B	0.1	10	100V
C12	CS31021	Erie 831/P100	2.2p	20	500V
C13	CS30166	Mullard C280AE/P100K	0.1	20	250V
C14	CS31027	Advance MD40	4.7	20	63V
C15	CS30947	Mullard C280AE/P47K-040	0.047	20	250V
C16	CS30474	Suflex 430/5-10/160	430p	5	160V
C17	CS30456	Suflex 22/5-10/160	22p	5	160V
C19	CS30995	Erie 831/K120051	470p	20	500V
C20	CS30951	Mullard C280AE/P100K-040	0.1	20	250V
C21	CS30217	Mullard C426AR/H2.5	2.5	+50,-10	64V
C22	CS30951	Mullard C280AE/P100K-040	0.1	20	250V
C23	CS31019	Erie 831/K350081	680	20	500V
C24	CS30958	Erie 831/K350081	1000p	20	500V
C25	CS31022	Erie 831/K7004	2200p	20	500V
C26	CS30475	Mullard C426AR/F12.5	12.5	+50,-10	25V
C27	CS31024	Erie 831/N3300	56p	20	500V
C28 & C18	CS30176	Mullard C426AR/E10	10	+50,-10	16V
C29	CS30951	Mullard C280AE/P100K-040	0.1	20	250V
C30	CS31019	Erie 831/K350081	680p	20	500V

Table 6-3 (Cont'd.)

Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
C31	CS30995	Erie 831/K120051	470p	20	500V
C32	CS30475	Mullard C426AR/F12.5	12.5	+50 -10	25V
C33	CS30175	Mullard C280AE/P10K	0.01	20	250V
C34	CS30995	Erie 831/K120051	470p	20	500V
C35	CS30226	Mullard C426AR/D16	16	+50, -10	10V
C36 C37	CS30954	Erie 801/K800011	0.01	+80, -20	750V
C38	CS31022	Erie 831/K7004	2200p	20	300V
C39	CS31023	Erie 831/N4200	68p	20	300V
C40	CS31017	Erie 831/N750	15p	20	500V
		Diodes			
D1	BS2542	STC 1N4148			
D2	Not Used				
D3	Not Used				
D4	BS2542	STC 1N4148			
D5	BS2680	Mullard BZY88/C5V1 or Texas IS2051A			
D6	BS2683	Mullard BZY88/C6V8 or Texas IS2068A			
D7	BS2542	STC 1N4148			
D8	BS2542	STC 1N4148			
D9	BS2542	STC 1N4148			
D10	BS2542	STC 1N4148			
D11	BS2542	STC 1N4148			
D13	BS2542	STC 1N4148			
D14	BS2542	STC 1N4148			
D15	BS2545	ITT 2002			
		Resistors (fixed)			
R1	DS6248	Dubilier BTT	1 M	10	$\frac{1}{2}$W
R2	DS33794	Mullard MR25	47 k	2	$\frac{1}{2}$W

Table 6-3 (Cont'd.)

Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
R3	DS33756	Mullard MR25	1.2 k	2	½W
R4	DS33730	Mullard MR25	100	2	½W
R5	DS33748	Mullard MR25	560	2	½W
R6	DS33740	Mullard MR25	270	2	½W
R7	DS33750	Mullard MR25	680	2	½W
R8	DS33778	Mullard MR25	10 k	2	½W
R9	DS33772	Mullard MR25	5.6 k	2	½W
R10	DS33750	Mullard MR25	680	2	½W
R11	DS33750	Mullard MR25	680	2	½W
R12	DS33788	Mullard MR25	27 k	2	½W
R13	DS33766	Mullard MR25	3.3 k	2	½W
R14	DS33766	Mullard MR25	3.3 k	2	½W
R15	DS33746	Mullard MR25	470	2	½W
R16	DS33746	Mullard MR25	470	2	½W
R17	DS33760	Mullard MR25	1.8 k	2	½W
R18	DS33760	Mullard MR25	1.8 k	2	½W
R19	DS33758	Mullard MR25	1.5 k	2	½W
R20	DS33790	Mullard MR25	33 k	2	½W
R21	DS33762	Mullard MR25	2.2 k	2	½W
R22	DS33706	Mullard MR25	10	2	½W
R23	DS33802	Mullard MR25	100 k	2	½W
R24	DS33788	Mullard MR25	27 k	2	½W
R25	DS33776	Mullard MR25	8.2 k	2	½W
R26	DS33742	Mullard MR25	330	2	½W
R27	DS33706	Mullard MR25	10	2	½W
R28	DS33766	Mullard MR25	3.3 k	2	½W
R29	DS33766	Mullard MR25	3.3 k	2	½W
R30	DS33877	Mullard MR25	3.01 k	1	-
R31	DS33778	Mullard MR25	10 k	2	½W
R32	DS33788	Mullard MR25	27 k	2	½W
R33	DS33780	Mullard MR25	12 k	2	½W
R34	DS32069	Welwyn 4014 150 ppm/°C	10.1 k	1	

Table 6-3 (Cont'd.)

Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
R35	DS33878	Mullard MR25	8.87 k	1	-
R36	DS32381	Welwyn 4014 150 ppm/°C	900	1	-
R37	DS33879	Mullard MR25	100	1	-
R38	DS33754	Mullard MR25	1 k	2	½W
R39	DS33776	Mullard MR25	8.2 k	2	½W
R40	DS32363	Electrosil TR5 or Welwyn MR5	22 k	2	½W
R41	DS33722	Mullard MR25	47	2	½W
R42	DS32358	Electrosil TR5 or Welwyn MR5	680	2	½W
R43	DS33728	Mullard MR25	82	2	½W
R44	DS33742	Mullard MR25	330	2	½W
R45	DS33742	Mullard MR25	330	2	½W
R46	DS33754	Mullard MR25	1 k	2	½W
R47	DS7480	Electrosil TR5 or Welwyn MR5	5.6 k	2	½W
R48	DS33754	Mullard MR25	1 k	2	½W
R49	DS33754	Mullard MR25	1 k	2	½W
R50	DS33774	Mullard MR25	6.8 k	2	½W
R51	DS33754	Mullard MR25	1 k	2	½W
R52	DS33746	Mullard MR25	470	2	½W
R53	DS33752	Mullard MR25	820	2	½W
R54	DS33770	Mullard MR25	4.7 k	2	½W
R55	DS33778	Mullard MR25	10 k	2	½W
R56	DS33788	Mullard MR25	27 k	2	½W
R57	DS33790	Mullard MR25	33 k	2	½W
R58	DS33790	Mullard MR25	33 k	2	½W
R59	DS33754	Mullard MR25	1 k	2	½W
R60	DS33760	Mullard MR25	1.8 k	2	½W
R61	DS33782	Mullard MR25	15 k	2	½W
R62	DS33722	Mullard MR25	47	2	½W
R63	DS33754	Mullard MR25	1 k	2	½W
R64	DS6248	Dubilier BTT	1 M	10	½W
R65	DS33802	Mullard MR25	100 k	2	½W

Table 6-3 (Cont'd.)

Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
R66	DS33758	Mullard MR25	1.5 k	2	½W
R67	DS33784	Mullard MR25	18 k	2	½W
R68	DS33754	Mullard MR25	1 k	2	½W
R69	DS7479	Electrosil TR5 or Welwyn MR5	1 k	2	½W
R70	DS33792	Mullard MR25	39 k	2	½W
R71	DS33744	Mullard MR25	390	2	½W
R72	DS7479	Electrosil TR5 or Welwyn MR5	1.2 k	2	½W
R73	DS33764	Mullard MR25	2.7 k	2	½W
R74	DS33730	Mullard MR25	100	2	½W
R75	DS33776	Mullard MR25	8.2 k	2	½W
R76	DS33776	Mullard MR25	8.2 k	2	½W
R77	DS33744	Mullard MR25	390	2	½W
R78	DS33764	Mullard MR25	2.7 k	2	½W
R79	DS33762	Mullard MR25	2.2 k	2	½W
R80	DS	Welwyn F75P	6.8 k	2	½W
R81	DS33758	Mullard MR25	1.5 k	2	½W
R82	DS33764	Mullard MR25	2.7 k	2	½W
R83	DS33766	Mullard MR25	3.3 k	2	½W
R84	DS33776	Mullard MR25	8.2 k	2	½W
R85	DS	Welwyn F75P	6.8 k	2	½W
R86	DS33758	Mullard MR25	1.5 k	2	½W
R87	DS33724	Mullard MR25	56	2	½W
R88	DS33730	Mullard MR25	100	2	½W
R89	DS33714	Mullard MR25	22	2	½W
R90	DS33714	Mullard MR25	22	2	½W
R91	DS33740	Mullard MR25	270	2	½W
R97	DS33754	Mullard MR25	1 k	2	½W
R98	DS32359	Electrosil TR5 or Welwyn MR5	4.7 k	2	½W
R99	DS33730	Mullard MR25	100	2	½W
R100	DS33730	Mullard MR25	100	2	½W
R101	DS33764	Mullard MR25	2.7 k	2	½W
R102	DS33734	Mullard MR25	150	2	½W

Table 6-3 (Cont'd.)

Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
R103	DS33790	Mullard MR25	33 k	2	½W
R104	DS33810	Mullard MR25	220 k	2	½W
R105	DS33770	Mullard MR25	4.7 k	2	½W
R106	DS33734	Mullard MR25	150	2	½W
		Resistors (Variable) (Ω)			
RV1	FS10299	Plessey Type MP/PC Linear	1 k	20	¼W
RV2	FS10299	Plessey Type MP/PC Linear	1 k	20	¼W
RV3	FS10297	Plessey Type MP/PC Linear	470	20	¼W
RV4	FS10301	Plessey Type MP/PC Linear	22 k	20	¼W
RV5	FS10301	Plessey Type MP/PC Linear	22 k	20	¼W
RV6	FS10301	Plessey Type MP/PC Linear	22 k	20	¼W
RV7	FS33880	Plessey Type MP/PC Linear	220	20	¼W
RV8	FS10315	Plessey Type MP/PC Linear	4.7 k	20	¼W
RV9	FS10364	Plessey Type MP/PC Linear	220 k	20	¼W
		Transistors			
VT1	BS2944	Texas BF244A			
VT2	BS2756	Texas TIS48 or Ferranti ZTX313			
VT3	BS2756	Texas TIS48 or Ferranti ZTX313			
VT4	BS2949	Fairchild 2N5139			
VT5		Mullard BSV68			
VT6	BS2561	Mullard BF178			
VT7	BS2518	Mullard BC108			
VT8	BS2518	Mullard BC108			
VT9	BS2518	Mullard BC108			
VT12	BS2756	Texas TIS48 or Ferranti ZTX313			
VT15	BS2944	Texas BF244A			
VT16	BS2518	Mullard BC108			
VT17	BS2518	Mullard BC108			
VT18	BS2518	Mullard BC108			
VT19	BS2949	Fairchild 2N5139			

Table 6-3 (Cont'd.)

Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
VT20	BS2518	Mullard BC108			
VT21	BS2944	Texas BF244A			
VT22	BS2945	Ferranti ZTX503L			
VT23	BS2945	Ferranti ZTX503L			
VT24	BS2945	Ferranti ZTX503L			
VT25	BS2518	Mullard BC108			
VT26	BS2561	Mullard BF178			
VT27	BS2561	Mullard BF178			
VT28	BS2518	Mullard BC108			
VT29	BS2945	Ferranti ZTX503L			
		Miscellaneous			
L1	ES8372	H.F. choke:Painton 58/10/0021/10 Type C12	470 µH	10	-
L2	ES8372	H.F. choke: Painton 58/10/0021/10 Type C12	470 µH	10	-
N1	BS2705	Integrated circuit: Texas SN72710N			
N2	BS2550	Integrated circuit: Texas SN7400N or Mullard FJH131			
N3	BS2550	Integrated circuit: Texas SN7400N or Mullard FJH131			
N4	BS2946	Integrated circuit: Texas SN7401AN			

TABLE 6-4 VERTICAL AMPLIFIER, X3

Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
		Capacitors			
C1	CS30192	Mullard C004AE/6E	0.8p-7p	-	-
C2	CS4745	Mullard C426AR/D64	64	+50 -10	10V
C3	CS30954	Erie 801/K800011	0.01	+80 -20	250V
C4	CS30229	Mullard C426AR/D200	200	+50, -10	10V
C5	Not Used				
C6	CS30196	Steatite 10S/TRIKO/06	4p-20p	-	250V
C7	CS30951	Mullard C280AE/P100K-040	0.1	20	250V
C8	CS30229	Mullard C426AR/D200	200	+50 -10	10V
C9	CS30229	Mullard C426AR/D200	200	+50 -10	10V
C10	CS30191	Steatite 10S/TRIKO/06	10p-60p	-	250V
C11	CS30951	Mullard C280AE/P100K-040	0.1	20	250V
C12	CS31000	Erie 831/N750	22p	20	500V
C13	Not Used				
C14	CS30951	Mullard C280AE/P100K-040	0.1	20	250V
C15	CS30192	Mullard C004EA/6E	0.8p-7p	-	-
C16	CS4745	Mullard C426AR/D64	64	+50, -10	10V
C17	CS30954	Erie 801/K800011	0.01	+80, -20	250V
C18	CS30229	Mullard C426AR/D200	200	+50, -10	10V
C19	CS30954	Erie 801/K800011	0.01	+80, -20	250V
C20	CS30196	Steatite 10S/TRIKO/06	4p-20p	-	250V
C21	CS30951	Mullard C280AE/P100K-040	0.1	20	250V
C22	CS30229	Mullard C426AR/D200	200	+50, -10	10V
C23	Not Used				
C24	CS30191	Steatite 10S/TRIKO/06	10p-60p	-	250V
C25	CS30951	Mullard C280AE/P100K-040	0.1	20	250V
C26	CS31000	Erie 831/N750	22p	20	500V
C27	Not Used				
C28	CS31017	Erie 831/N750	15p	20	500V
C29	CS31017	Erie 831/N750	15p	20	500V
C30	CS31017	Erie 831/N750	15p	20	500V

Table 6-4 (Cont'd.)

Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
C31	CS31017	Erie 831/N750	15p	20	500V
C32	Not Used				
C33	Not Used				
C34	CS30943	Erie 831/K350081	1500p	25	500V
C35	CS30951	Mullard C280AE/P100K-040	0.1	20	250V
C36	CS30951	Mullard C280AE/P100K-040	0.1	20	250V
C37	CS31020	Erie 831/N1500	47p	20	500V
C40	CS30957	Erie 831/N1500	33p	20	500V
C41	CS30957	Erie 831/N1500	33p	20	500V
C42	CS31008	Erie 861/NPO	2.2p	20	500V
C43	CS31008	Erie 861/NPO	2.2p	20	500V
		Diodes			
D1	BS2963	Siliconex EPAD 500			
D2	BS2542	STC 1N4148			
D3	BS2542	STC 1N4148			
D4	BS2542	STC 1N4148			
D5	BS2542	STC 1N4148			
D6	BS2623 or BS2681	Mullard BZY88/C5V6 or Texas IS2082A			
D7	Not Used				
D8	Not Used				
D9	BS2627 or BS2683	Mullard BZY88/C6V8 Texas IS2068A			
D10	BS2624 BS2685	Mullard BZY88/C8V2 or Texas IS2082A			
D11	BS2963	Siliconex EPAD 500			
D12	BS2542	STC 1N4148			
D13	BS2542	STC 1N4148			
D14	BS2542	STC 1N4148			
D15	BS2542	STC 1N4148			
D16	BS2623 or BS2681	Mullard BZY88/C5V6 or Texas IS2082A			

Table 6-4 (Cont'd.)

Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
D17	Not Used				
D18	BS2623 or BS2681	Mullard BZY88/C5V6 or Texas IS2082A			
D19	BS2542	STC 1N4148			
D20	BS2542	STC 1N4148			
D21	BS2623 or BS2681	Mullard BZY88/C5V6 or Texas IS2082A			
		Resistors (fixed) (Ω)			
R1	DS32361	Mullard MR25	100	2	½W
R2	DS32373	Mullard MR25	39 k	2	½W
R3	DS32364	Mullard MR25	220	2	½W
R4	DS32440	Mullard MR25	15 k	2	½W
R5	DS32361	Mullard MR25	100	2	½W
R6	DS32375	Mullard MR25	1.8 k	2	½W
R7	DS32361	Mullard MR25	100	2	½W
R8	DS7479	Mullard MR25	1 k	2	½W
R9	DS32364	Mullard MR25	220	2	½W
R10	DS32127	Mullard MR25	470	2	½W
R11	DS32360	Mullard MR25	47 k	2	½W
R12	DS32234	Mullard MR25	47	2	½W
R13	DS32359	Mullard MR25	4.7 k	2	½W
R14	DS32402	Mullard MR25	27	2	½W
R15	DS32357	Mullard MR25	1.5 k	2	½W
R16	DS33127	Mullard MR25	180 k	2	½W
R17	DS33748	Mullard MR25	560	2	½W
R18	DS33748	Mullard MR25	560	2	½W
R19	DS32385	Mullard MR25	150	2	½W
R20	DS32362	Mullard MR25	3.3 k	2	½W
R21	DS32361	Mullard MR25	100	2	½W
R22	DS7302	Mullard MR25	10	2	½W
R23	DS6248	Dubilier BTT	1 M	10	¼W

Table 6-4 (Cont'd.)

Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
R24	DS7480	Mullard MR25	5.6 k	2	½W
R25	DS32375	Mullard MR25	1.8 k	2	½W
R26	DS7491	Mullard MR25	1.2 k	2	½W
R27	DS7491	Mullard MR25	1.2 k	2	½W
R28	DS32128	Mullard MR25	330	2	½W
R29	DS33726	Mullard MR25	68	2	½W
R30	DS33726	Mullard MR25	68	2	½W
R31	DS33726	Mullard MR25	68	2	½W
R32	DS7526	Mullard MR25	10 k	2	½W
R33	DS32397	Mullard MR25	82	2	½W
R34	DS32128	Mullard MR25	330	2	½W
R35	DS7479	Mullard MR25	1 k	2	½W
R36	DS32386	Mullard MR25	33	2	½W
R37	DS7491	Mullard MR25	1.2 k	2	½W
R38	DS32126	Mullard MR25	390	2	½W
R39	DS32397	Mullard MR25	82	2	½W
R40	DS32367	Mullard MR25	820	2	½W
R41	DS7491	Mullard MR25	1.2 k	2	½W
R42	DS32128	Mullard MR25	330	2	½W
R43	DS32409	Mullard MR25	3.9 k	2	½W
R44	DS32367	Mullard MR25	820	2	½W
R45	DS32127	Mullard MR25	470	2	½W
R46	DS32127	Mullard MR25	470	2	½W
R47	DS32361	Mullard MR25	100	2	½W
R48	DS32373	Mullard MR25	39 k	2	½W
R49	DS32364	Mullard MR25	220	2	½W
R50	DS32440	Mullard MR25	15 k	2	½W
R51	DS32361	Mullard MR25	100	2	½W
R52	DS32375	Mullard MR25	1.8 k	2	½W
R53	DS32361	Mullard MR25	100	2	½W
R54	DS7479	Mullard MR25	1 k	2	½W

Table 6-4 (Cont'd.)

Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
R55	DS32364	Mullard MR25	220	2	½W
R56	DS32360	Mullard MR25	47 k	2	½W
R57	DS32127	Mullard MR25	470	2	½W
R58	DS32359	Mullard MR25	4.7 k	2	½W
R59	DS32234	Mullard MR25	47	2	½W
R60	DS32402	Electrosil TR5 or Welwyn MR5	27	2	½W
R61	DS32357	Electrosil TR5 or Welwyn MR5	1.5 k	2	½W
R62	DS33127	Electrosil TR5 or Welwyn MR5	180 k	2	½W
R63	DS7479	Electrosil TR5 or Welwyn MR5	1 k	2	½W
R64	DS32364	Electrosil TR5 or Welwyn MR5	220	2	½W
R65	DS32385	Electrosil TR5 or Welwyn MR5	150	2	½W
R66	DS32362	Electrosil TR5 or Welwyn MR5	3.3 k	2	½W
R67	DS32361	Electrosil TR5 or Welwyn MR5	100	2	½W
R68	DS6248	Dubilier BTT	1 M	10	¼W
R69	DS7480	Electrosil TR5 or Welwyn MR5	5.6 k	2	½W
R70	DS32375	Electrosil TR5 or Welwyn MR5	1.8 k	2	½W
R71	DS7491	Electrosil TR5 or Welwyn MR5	1.2 k	2	½W
R72	DS7491	Electrosil TR5 or Welwyn MR5	1.2 k	2	½W
R73	DS7302	Electrosil TR5 or Welwyn MR5	10	2	½W
R74	DS32128	Electrosil TR5 or Welwyn MR5	330	2	½W
R75	DS33726	Mullard MR25	68	2	½W
R76	DS33726	Mullard MR25	68	2	½W
R77	DS33726	Mullard MR25	68	2	½W
R78	DS7526	Electrosil TR5 or Welwyn MR5	10 k	2	½W
R79	DS32128	Electrosil TR5 or Welwyn MR5	330	2	½W
R80	DS7479	Electrosil TR5 or Welwyn MR5	1 k	2	½W
R81	DS7491	Electrosil TR5 or Welwyn MR5	1.2 k	2	½W
R82	DS32126	Electrosil TR5 or Welwyn MR5	390	2	½W
R83	DS32367	Electrosil TR5 or Welwyn MR5	820	2	½W
R84	DS7491	Electrosil TR5 or Welwyn MR5	1.2 k	2	½W
R85	DS32128	Electrosil TR5 or Welwyn MR5	330	2	½W

Table 6-4 (Cont'd.)

Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
R86	DS32409	Electrosil TR5 or Welwyn MR5	3.9 k	2	½W
R87	DS32367	Electrosil TR5 or Welwyn MR5	820	2	½W
R88	DS32132	Electrosil TR5 or Welwyn MR5	2.7 k	2	½W
R89	DS32359	Electrosil TR5 or Welwyn MR5	4.7 k	2	½W
R90	DS7478	Electrosil TR5 or Welwyn MR5	12 k	2	½W
R91	DS7478	Electrosil TR5 or Welwyn MR5	12 k	2	½W
R92	DS32132	Electrosil TR5 or Welwyn MR5	2.7 k	2	½W
R93	DS32359	Electrosil TR5 or Welwyn MR5	4.7 k	2	½W
R94	DS32128	Electrosil TR5 or Welwyn MR5	330	2	½W
R95	DS32375	Electrosil TR5 or Welwyn MR5	1.8 k	2	½W
R96	DS32367	Electrosil TR5 or Welwyn MR5	820	2	½W
R97	DS32385	Electrosil TR5 or Welwyn MR5	150	2	½W
R98	DS32385	Electrosil TR5 or Welwyn MR5	150	2	½W
R99	DS7302	Electrosil TR5 or Welwyn MR5	10	2	½W
R100	DS7479	Electrosil TR5 or Welwyn MR5	1 k	2	½W
R101	DS32359	Electrosil TR5 or Welwyn MR5	4.7 k	2	½W
R102	Not Used				
R103	DS32367	Electrosil TR5 or Welwyn MR5	820	2	½W
R104	DS32357	Electrosil TR5 or Welwyn MR5	1.5 k	2	½W
R105	DS32357	Electrosil TR5 or Welwyn MR5	1.5 k	2	½W
R106	DS32363	Electrosil TR5 or Welwyn MR5	22 k	2	½W
R107	DS32128	Electrosil TR5 or Welwyn MR5	330	2	½W
R108	Not Used				
R109	DS32356	Electrosil TR5 or Welwyn MR5	180	2	½W
R110	DS32385	Electrosil TR5 or Welwyn MR5	150	2	½W
R111	DS32385	Electrosil TR5 or Welwyn MR5	150	2	½W
R112	DS32386	Electrosil TR5 or Welwyn MR5	33	2	½W
R113	DS32126	Electrosil TR5 or Welwyn MR5	390	2	½W
R114	DS33794	Mullard MR25	47 k	2	½W
R115	DS33794	Mullard MR25	47 k	2	½W
R116	DS32363	Mullard MR25	22 k	2	½W

Table 6-4 (Cont'd.)

Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
R117	DS32363	Mullard MR25	22 k	2	½W
		Resistors (Variable) (Ω)			
RV1	FS10300	Plessey Type MP/PC Linear	47 k	20	¼W
RV2	FS10415	Plessey Type MP/PC Linear	47	20	¼W
RV3	FS10308	Plessey Type MP/PC Linear	2.2 k	20	¼W
RV4	FS10300	Plessey Type MP/PC Linear	47 k	20	¼W
RV5	FS10415	Plessey Type MP/PC Linear	47	20	¼W
RV6	FS10308	Plessey Type MP/PC Linear	2.2 k	20	¼W
RV7	FS10297	Plessey Type MP/PC Linear	470	20	¼W
RV8	FS10297	Plessey Type MP/PC Linear	470	20	¼W
		Transistors			
VT1	BS2944	Texas BF244A			
VT2	BS2949	Fairchild 2N5139			
VT3	BS2756	Texas TIS48 or Ferranti ZTX313			
VT4	BS2756	Texas TIS48 or Ferranti ZTX313			
VT5	BS2756	Texas TIS48 or Ferranti ZTX313			
VT6	BS2949	Fairchild 2N5139			
VT7	BS2756	Texas TIS48 or Ferranti ZTX313			
VT8	BS2756	Texas TIS48 or Ferranti ZTX313			
VT9	BS2949	Fairchild 2N5139			
VT10	BS2949	Fairchild 2N5139			
VT11	BS2756	Texas TIS48 or Ferranti ZTX313			
VT12	BS2756	Texas TIS48 or Ferranti ZTX313			
VT13	BS2949	Fairchild 2N5139			
VT14	BS2944	Texas BF244A			
VT15	BS2949	Fairchild 2N5139			
VT16	BS2756	Texas TIS48 or Ferranti ZTX313			
VT17	BS2756	Texas TIS48 or Ferranti ZTX313			
VT18	BS2756	Texas TIS48 or Ferranti ZTX313			
VT19	BS2949	Fairchild 2N5139			

Table 6-4 (Cont'd.)

Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
VT20	BS2756	Texas TIS48 or Ferranti ZTX313			
VT21	BS2756	Texas TIS48 or Ferranti ZTX313			
VT22	BS2949	Fairchild 2N5139			
VT23	BS2949	Fairchild 2N5139			
VT24	BS2756	Texas TIS48 or Ferranti ZTX313			
VT25	BS2756	Texas TIS48 or Ferranti ZTX313			
VT26	BS2949	Fairchild 2N5139			
VT27	BS2756	Texas TIS48 or Ferranti ZTX313			
VT28	BS2756	Texas TIS48 or Ferranti ZTX313			
VT29	BS2756	Texas TIS48 or Ferranti ZTX313			
VT30	BS2756	Texas TIS48 or Ferranti ZTX313			
VT31	Not Used				
VT32	BS2756	Texas TIS48 or Ferranti ZTX313			
VT33	BS2518	Mullard BC108 or Ferranti ZTX108			
VT34	BS2518	Mullard BC108 or Ferranti ZTX108			

TABLE 6-5 VERTICAL OUTPUT AMPLIFIER X4

Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
		Capacitors			
C1	CS30951	Mullard C280AE/P100K-040	0.1	20	250V
C2	CS30190	Steatite 10S,TRIKO/06. N750	10p-40p		250V
C3	CS31039	Mullard C333CC/C68E	68p	2	63V
C4	CS31039	Mullard C333CC/C68E	68p	2	63V
C5	CS31000	Erie 831/N220	22p	20	500V
C6	CS30995	Erie 831/K120051	470p	20	500V
C7	CS30947	Mullard C280AE/P47K-040	0.047	20	250V
		Resistors (fixed) (Ω)			
R1	DS32127	Electrosil TR5 or Mullard MR25	470	2	½W
R2	DS32397	Electrosil TR5 or Welwyn MR5	82	2	½W
R3	DS32397	Electrosil TR5 or Welwyn MR5	82	2	½W
R4	DS7479	Electrosil TR5	1 k	2	½W
R5	DS7302	Electrosil TR5	10	2	½W
R6	DS7479	Electrosil TR5	1 k	2	½W
R7	DS32126	Electrosil TR5	390	2	½W
R8	Not Used				
R9	DS32127	Electrosil TR5 or Welwyn MR5	470	2	½W
R10	DS	Welwyn F75P	1 k	5	
R11	DS32398	Electrosil TR5	120	2	½W
R12	DS32385	Electrosil TR5	150	2	½W
R13	DS32410	Electrosil TR5	68	2	½W
R14	DS32127	Electrosil TR5	470	2	½W
R15	DS32131	Electrosil TR5	2.2 k	2	½W
R16	DS7302	Electrosil TR5 or Welwyn MR5	10	2	½W
R17	DS32440	Electrosil TR5	15 k	2	½W
R18	DS32372	Electrosil TR5 or Welwyn MR5	18 k	2	½W
R19	DS7479	Electrosil TR5	1 k	2	½W
R20	DS32385	Electrosil TR5	150	2	½W
R21	DS7302	Electrosil TR5	10	2	½W
R22	DS	Welwyn F75P	1 k	5	

Table 6-5 (Cont'd.)

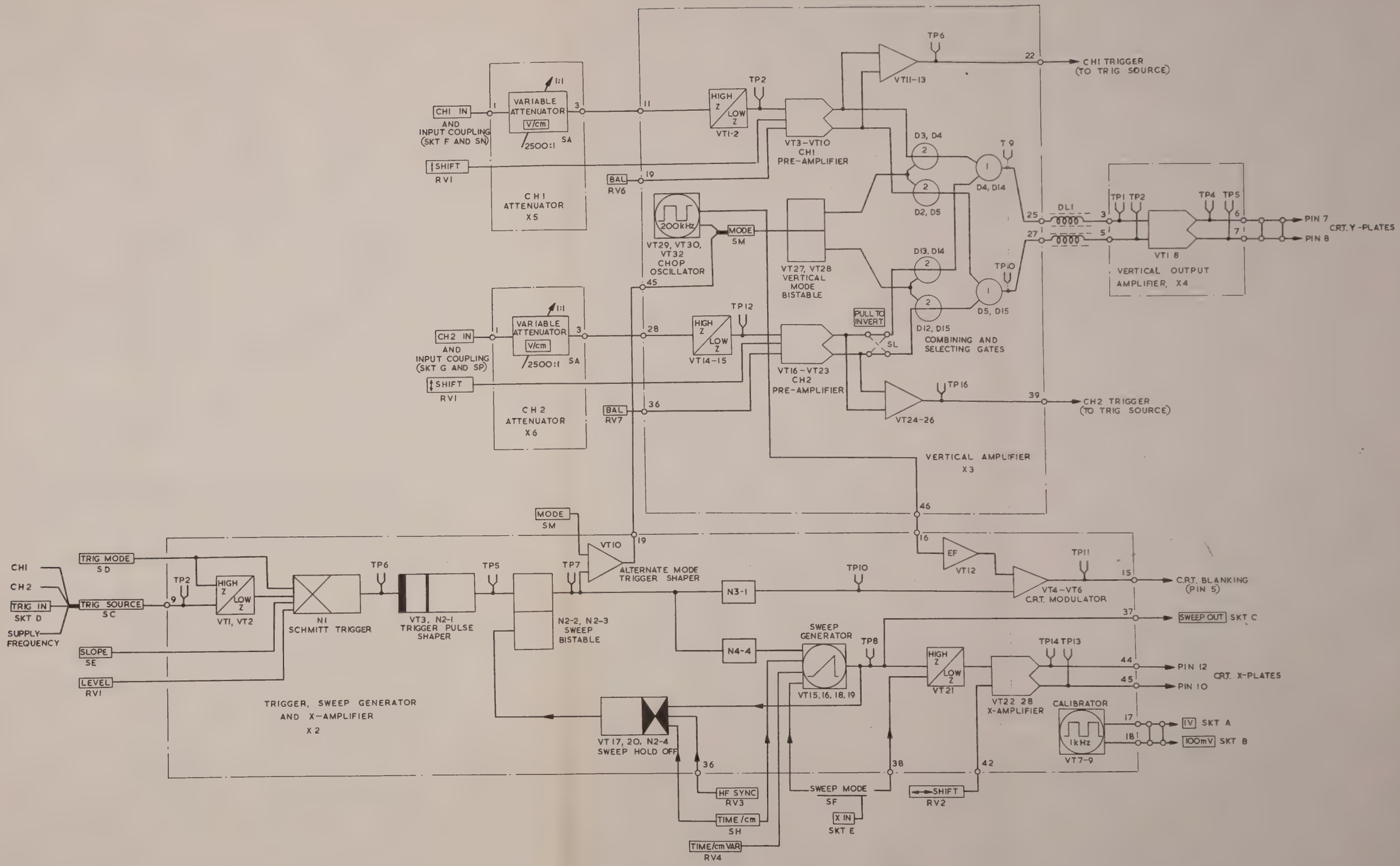
Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
R23	DS32398	Electrosil TR5	120	2	½W
R24	DS32126	Electrosil TR5	390	2	½W
		Transistors			
VT1	BS2622	Mullard BSX19			
VT2	BS2622	Mullard BSX19			
VT3	BS2622	Mullard BSX19			
VT4	BS2622	Mullard BSX19			
VT5	BS2943	Texas 2N3725 or Mullard BSX61			
VT6	BS2622	Mullard BSX19			
VT7	BS2943	Texas 2N3725 or Mullard BSX61			
VT8	BS2622	Mullard BSX19			

TABLE 6-6 ATTENUATOR, X5 AND X6

Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
		Capacitors			
C1	CS31007	Erie 861/N150	10p	5	500V
C2	CS30192	Mullard C004EA/6E	0.8p-6p	-	-
C3	CS30192	Mullard C004EA/6E	0.8p-6p	-	-
C4	CS31007	Erie 861/N150	10p	5	500V
C5	CS30962	Erie 861/N047	8.2p	5	500V
C6	CS30192	Mullard C004EA/6E	0.8p-6p	-	-
C7	CS30192	Mullard C004EA/6E	0.8p-6p	-	-
C8	CS30465	Suflex HS7	150p	10	160V
C9	CS30962	Erie 861/N047	8.2p	5	500V
C10	CS30192	Mullard C004EA/6E	0.8p-6p	-	-
C11	CS30192	Mullard C004EA/6E	0.8p-6p	-	-
C12	CS30548	Suflex HS7	1000p	10	63V
C13	CS30192	Mullard C004EA/6E	0.8p-6p	-	-
C14	CS31007	Erie 861/N150	10p	5	500V
C15	CS30192	Mullard C004EA/6E	0.8p-6p	-	-
C16	CS30192	Mullard C004EA/6E	0.8p-6p	-	-
C17	CS31008	Erie 861/NPO	2.2p	20	500V
C18	CS30192	Mullard C004EA/6E	0.8p-6p	-	-
C19	CS30168	Erie/K350081	1500p	20	500V
C20	CS31008	Erie 861/NPO	2.2p	20	500V
C21	CS30962	Erie 861/N047	8.2p	5	500V
C23	CS31004	Erie 861/NPO	4.7p	10	500V
		Resistors (Fixed) (Ω)			
R1	DS32065	Welwyn 4014 150 ppm/°C	900k	1	-
R2	DS32068	Welwyn 4014 150 ppm/°C	111k	1	-
R3	DS32066	Welwyn 4014 150 ppm/°C	990k	1	-
R4	DS32069	Welwyn 4014 150 ppm/°C	10.1k	1	-
R5	DS33874	Mullard MR30	1 M	1	-
R6	DS33876	Mullard MR25	1 k	1	-
R7	DS5195	Dubilier BTT	47	10	½ W

Table 6-6 (Cont'd.)

Cct. Ref.	SEL Part No.	Manufacturer/Reference	Value	Tol. ± %	Rating
R8	DS32392	Welwyn 4014 150 ppm/°C	600k	1	-
R9	DS32393	Welwyn 4014 150 ppm/°C	666k	1	-
R10	DS32072	Welwyn 4014 150 ppm/°C	800k	1	-
R11	DS32073	Welwyn 4014 150 ppm/°C	250k	1	-
R12	DS6192	Dubilier BTT	470k	10	½ W
R13	DS33874	Mullard MR30	1 M	1	-
R14	DS33714	Mullard MR25	22	2	-
R16	DS33744	Mullard MR25	390	2	-
R17	DS33718	Mullard MR25	33	2	-
R18	DS33738	Mullard MR25	220	2	-
R19	DS33742	Mullard MR25	330	2	-
		Resistors (Variable)			
RV1	DS33881	A.B. Electronics Type 45 Linear	220k	20	-
RV6	DS33873	A.B. Electronics Type 44	10k	20	-
RV7	DS33873	A.B. Electronics Type 44	10k	20	-
RV9	DS33882	A.B. Electronics Type 84P	47	20	-
RV11	DS33882	A.B. Electronics Type 84P	47	20	-



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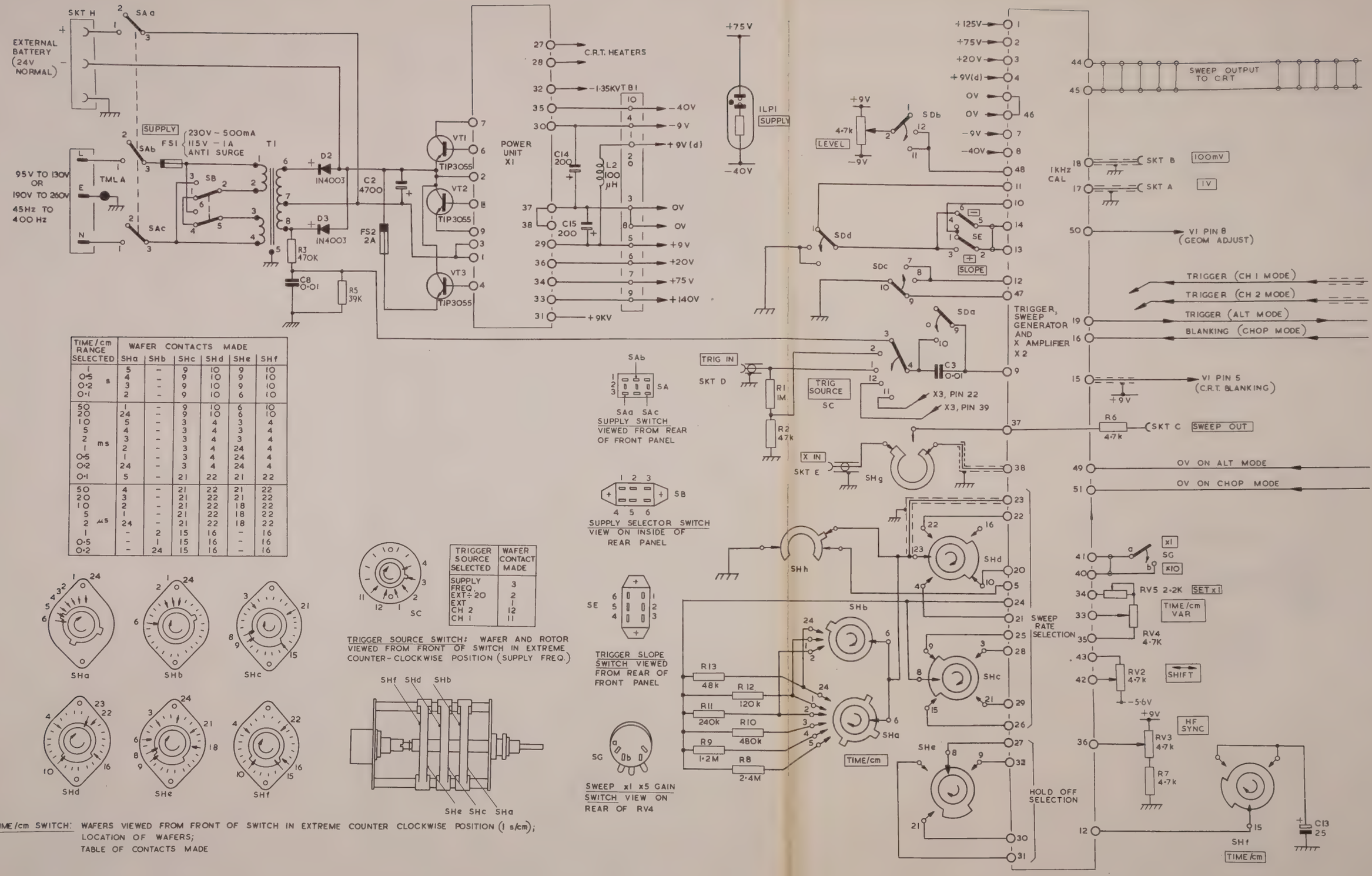
SM113 OSCILLOSCOPE. FIG.7.1
BLOCK SCHEMATIC.

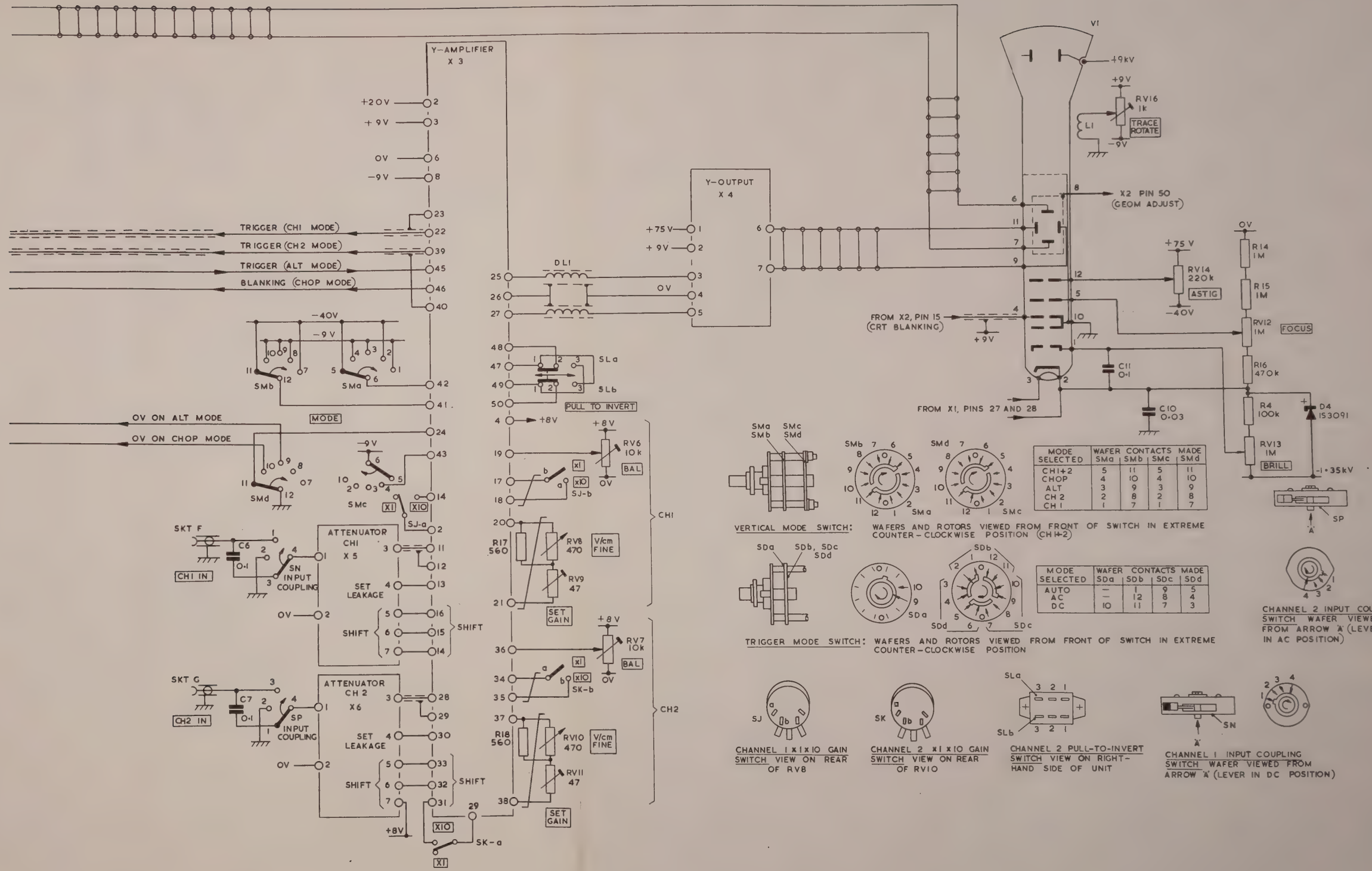


TIME/cm RANGE SELECTED		WAFER CONTACTS MADE					
		SHa	SHb	SHc	SHd	SHe	SHf
1	s	5	–	9	10	9	10
0·5		4	–	9	10	9	10
0·2		3	–	9	10	9	10
0·1		2	–	9	10	6	10
50		1	–	9	10	6	10
20		24	–	9	10	6	10
10		5	–	3	4	3	4
5		4	–	3	4	3	4
2	ms	3	–	3	4	3	4
1		2	–	3	4	24	4
0·5		1	–	3	4	24	4
0·2		24	–	3	4	24	4
0·1		5	–	21	22	21	22
50		4	–	21	22	21	22
20		3	–	21	22	21	22
10		2	–	21	22	18	22
5		1	–	21	22	18	22
2	µs	24	–	21	22	18	22
1		–	2	15	16	–	16
0·5		–	1	15	16	–	16
0·2		–	24	15	16	–	16

TRIGGER SOURCE SELECTED	WAFER CONTACT MADE
SUPPLY FREQ.	3
EXT ÷ 20	2
EXT	1
CH 2	12
CH 1	11

TIME/cm SWITCH: WAFERS VIEWED FROM FRONT OF SWITCH IN EXTREME COUNTER CLOCKWISE POSITION (1 s/cm);
LOCATION OF WAFERS;
TABLE OF CONTACTS MADE

FIG. 7.2 (SHEET 1) SM113 OSCILLOSCOPE.



MODE SELECTED	WAFER CONTACTS MADE SMa	SMb	SMc	SMd
CH1+2	5	11	5	11
CHOP	4	10	4	10
ALT	3	9	3	9
CH 2	2	8	2	8
CH 1	1	7	1	7

VERTICAL MODE SWITCH: WAFERS AND ROTORS VIEWED FROM FRONT OF SWITCH IN EXTREME COUNTER-CLOCKWISE POSITION (CH1+2)

MODE SELECTED	WAFER CONTACTS MADE SDa	SDb	SDc	SDd
AUTO	—	1	9	5
AC	—	12	8	4
DC	10	11	7	3

TRIGGER MODE SWITCH: WAFERS AND ROTORS VIEWED FROM FRONT OF SWITCH IN EXTREME COUNTER-CLOCKWISE POSITION

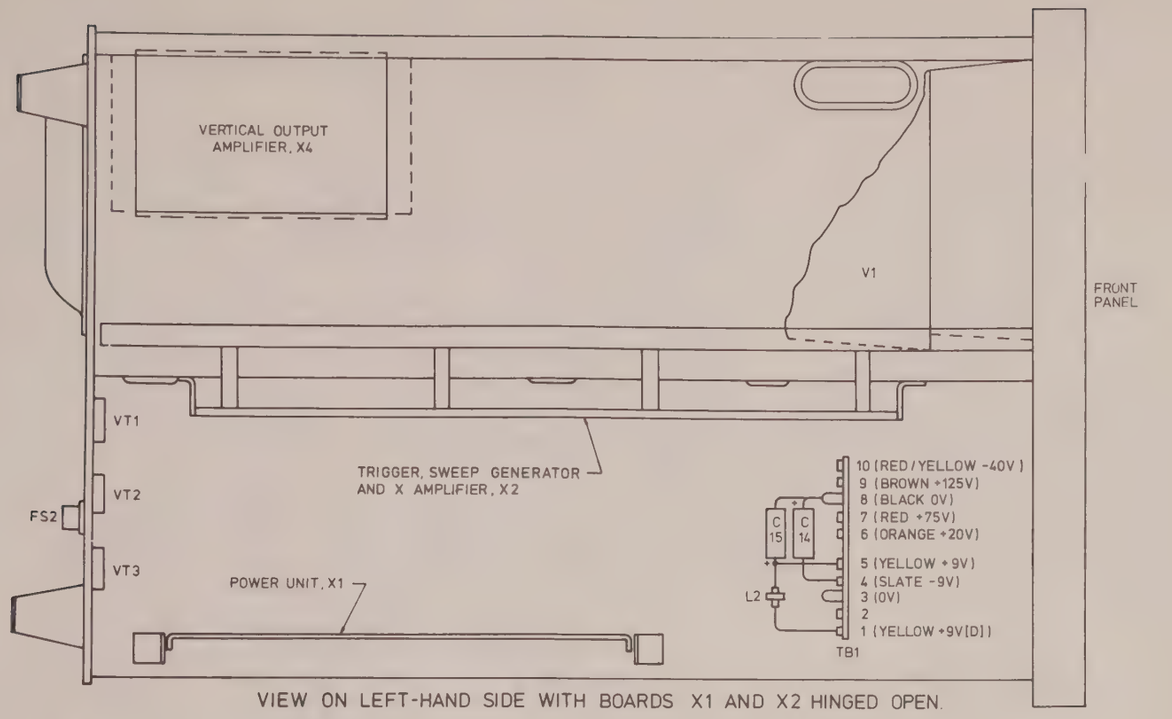
CHANNEL 2 INPUT COUPLING SWITCH WAFER VIEWED FROM ARROW 'A' (LEVER IN AC POSITION)

CHANNEL 1 x1 x10 GAIN SWITCH VIEW ON REAR OF RV8

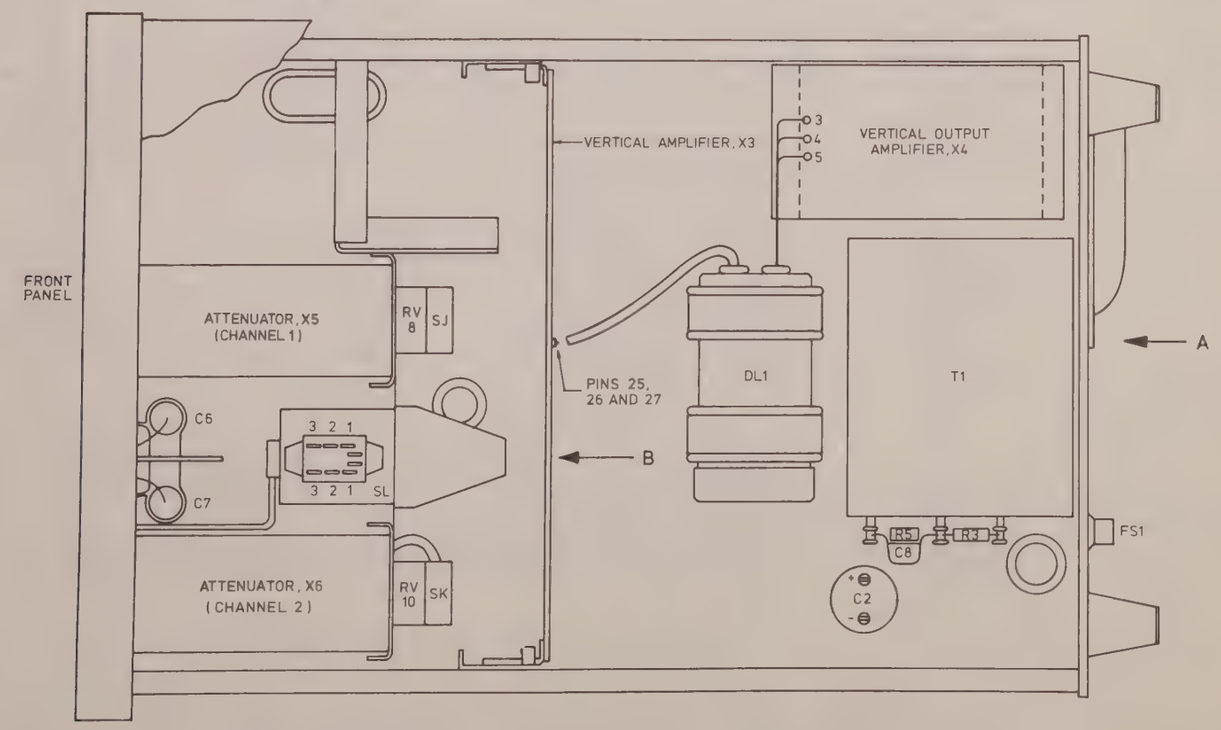
CHANNEL 2 x1 x10 GAIN SWITCH VIEW ON REAR OF RV10

CHANNEL 2 PULL-TO-INVERT SWITCH VIEW ON RIGHT-HAND SIDE OF UNIT

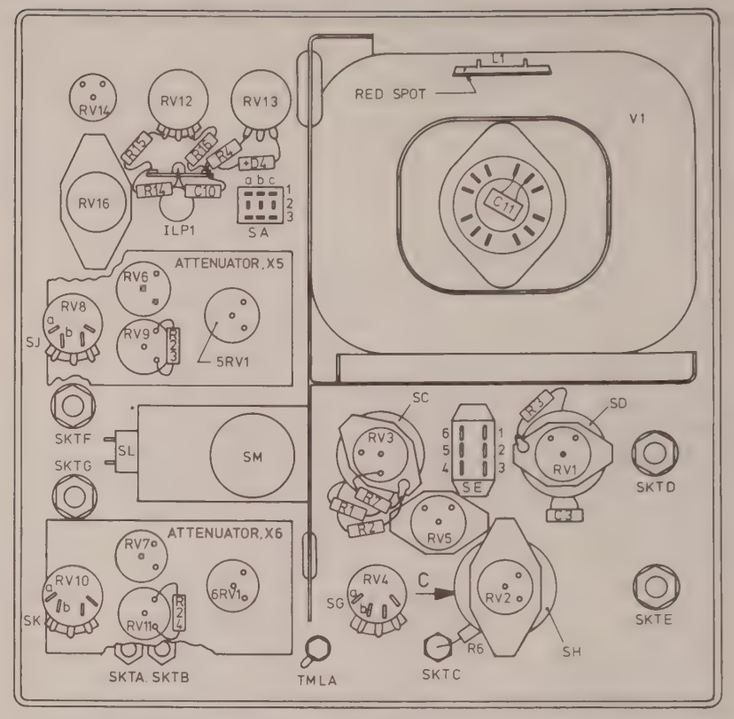
CHANNEL 1 INPUT COUPLING SWITCH WAFER VIEWED FROM ARROW 'A' (LEVER IN DC POSITION)



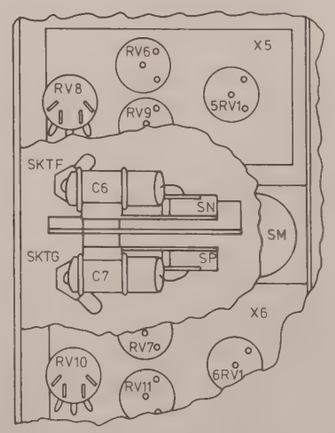
VIEW ON LEFT-HAND SIDE WITH BOARDS X1 AND X2 HINGED OPEN.



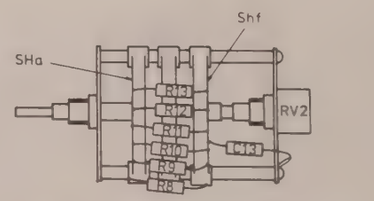
VIEW ON RIGHT-HAND SIDE WITH BOARD X3 HINGED OPEN.



SCRAP VIEW ON ARROW 'A' SHOWING REAR OF C.R.T. AND FRONT PANEL (OMITTING C6, C7, SN AND SP)

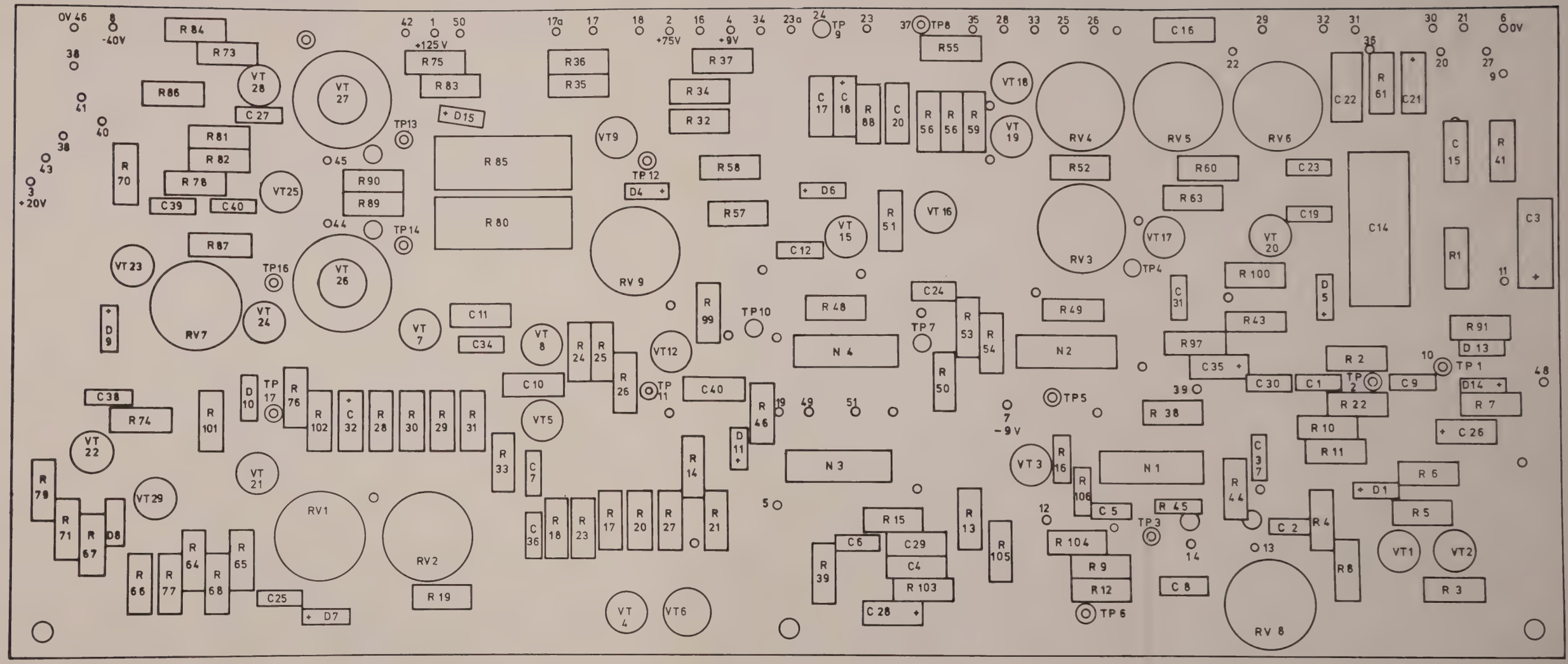


SCRAP VIEW ON ARROW 'B' SHOWING C6, C7, SN, AND SP.



SCRAP VIEW ON ARROW 'C' SHOWING COMPONENTS MOUNTED ON SH.

FIG. 7.2 (SHEET 3) SM113 OSCILLOSCOPE - COMPONENT LAYOUT.



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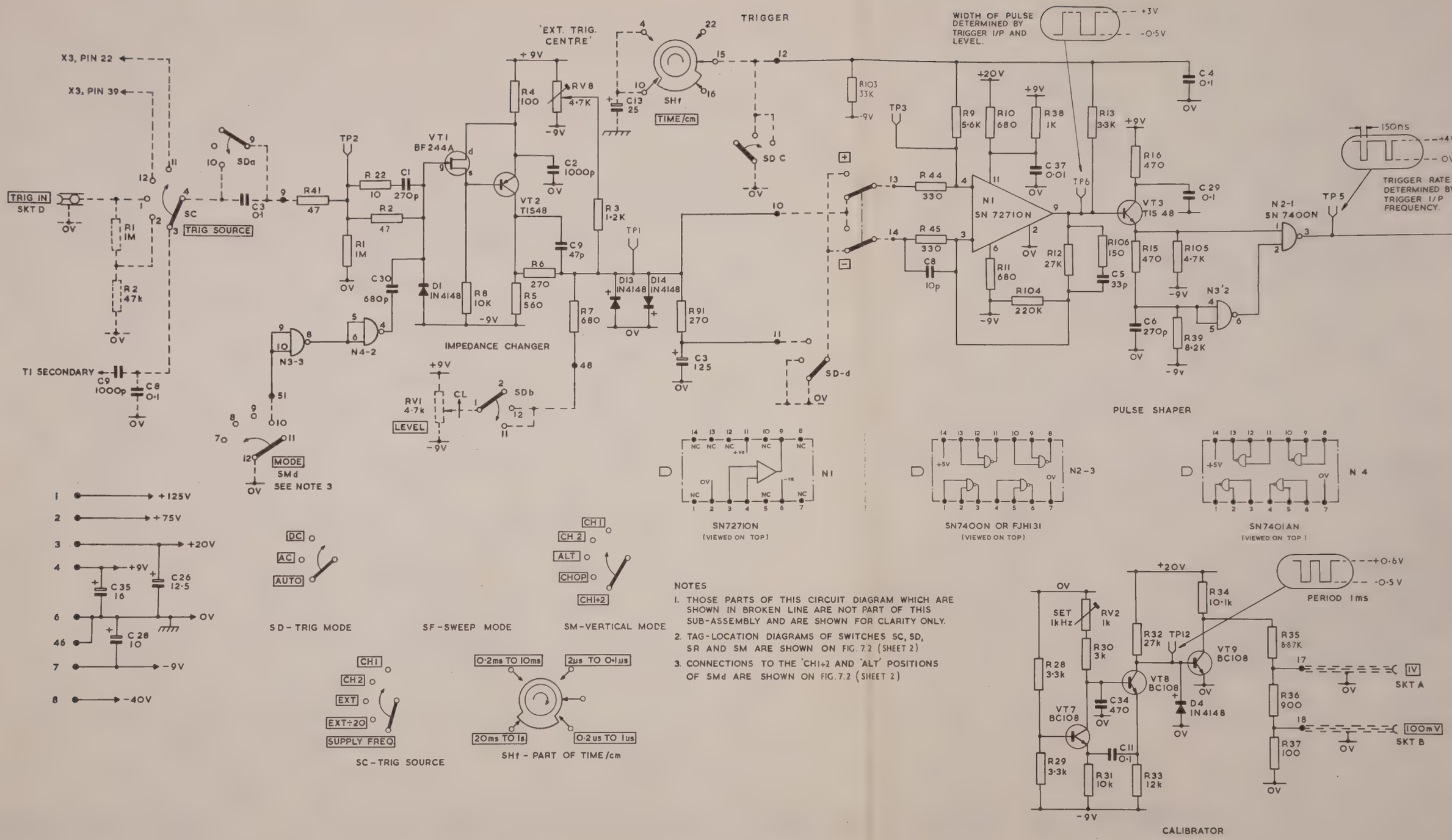
TRIGGER AND SWEEP GENERATOR - COMPONENT LAYOUT

FIG.7.3(SHEET 1)



NOTES

1. THOSE PARTS OF THIS CIRCUIT DIAGRAM WHICH ARE SHOWN IN BROKEN LINE ARE NOT PART OF THIS SUB-ASSEMBLY AND ARE SHOWN FOR CLARITY ONLY.
2. TAG-LOCATION DIAGRAMS OF SWITCHES SC, SD, SR AND SM ARE SHOWN ON FIG. 7.2 (SHEET 2)
3. CONNECTIONS TO THE 'CH1+2 AND 'ALT' POSITIONS OF SMd ARE SHOWN ON FIG. 7.2 (SHEET 2)

FIG. 7.3 (SHEET 2) TRIGGER AND SWEEP GENERATOR (TRIGGER AND CALIBRATOR)

CM 1004

HOLD-OFF WAIT
+3·5V +3V
-0V
SWEEP
NOTE. WAIT PERIOD IS OFTEN AT SAME LEVEL AS HOLD-OFF PERIOD.
TP7
-0V
SHh
N4-1
19 ALT TRIG OUT
N3-4
49 TO Y MODE SWITCH SM-d POSN. 3
D11 IN4148
CHOP MODE *
+70V (BLANKED.)
+55V
+10V (UNBLANKED.)
+70V (BLANKED)
+10V (UNBLANKED)
* NOTE. CHOP WAVEFORM NOT SYNCHRONISED TO MAIN BLANKING WAVEFORM.
C7 68p
R24 27k
R25 8·2k
VT5 2N5400
C10 0·047
R23 100k
R26 330
TP11
15 C.R.T. BLANKING (VI PIN 5 -
+9V 15a
+9V
R27 10
R21 2·2k
VT6 BF178
VT4 2N5139
R17 1·8k
R18 1·8k
R19 1·5k
R20 33k
RV1 1k SET BLANKING LEVEL
-9V
C.R.T. MODULATOR
CHOPPED BLANKING IN 16
R99 100
VT12 TIS48
+9V
R14 3·3k
-9V
+9V
-0·5V
SWEEP DURATION
TP10
N4-4
N2-2
N2-3
N3-1
C12 2·2p
R46 1K
+5V
+75V
R57 33k
TP9
24
OV
C14 4·7
C15 0·047
VT15 BF244A
R88 100
C17 22p
OV
SHb
TIME/cm
SHd
SHa
SHc
R13 48k
R12 120K
R11 240K
R10 480K
R9 1·2M
R8 2·4M
CAL 1SEC/CM TO 20MS/CM
CAL 10MS/CM TO 0·2 MS/CM
RV4 22K
RV6 22K
RV5 22K
CAL 1µS/CM TO 0·2 µS/CM
R55 10K
VT19 2N5139
VT18 BC108
R58 33K
CAL X1
2·2K
D6 BZY88 /C6V2
RV4 4·7k
TIME/ cmVAR
C18 10
C16 430p
C20 0·1
R56 33K
R59 1K
+20V
VT16 BC108
R51 1k
HOLD-OFF
+2·5V
+1·25V
OV
SWEEP
SET SWEEP LENGTH
RV3 470
R52 470
R53 820
VT17 BC108
R54 4·7K
-9V
C19 470p
C21 2·5
C22 0·1
C23 680p
HF SYNC
RV3 4·7k
R7 4·7k
R61 15k
R63 1K
VT20 BC108
R60 1·8K
R100 100
TP4
SWEEP HOLD OFF
+5V
R48 1K
C24 1000P
N4-3
R50 6·8K
R49 1K
-9V
+18·5V
-0·5V
SKT C
SWEEP OUT
R6 4·7k
SHg
TP8
R62 47
X IN
SKT E
C25 2200P
R64 1M
R65 100k
+20V
R68 1k
VT21 BF244A
TP17
TO X AMPLIFIER
D7 IN4148
R70 39k
-40V
-9V
+10V
+2V
IMPEDANCE CHANGER
R97 1k
C31 470p

NOTES.

1. THOSE PARTS OF THIS CIRCUIT DIAGRAM WHICH ARE SHOWN IN BROKEN LINE ARE NOT PART OF THIS SUB-ASSEMBLY AND ARE SHOWN FOR CLARITY ONLY.
2. TAG LOCATION DIAGRAMS OF SH AND SM ARE SHOWN ON FIG. 7. 2 SHEETS 1, 4. 2 RESPECTIVELY.
3. CONNECTIONS TO THE 'CH1+2' AND 'CHOP' POSITIONS OF SMd ARE SHOWN ON. FIG. 7. 2 (SHEET 2.)
4. POWER SUPPLY CONNECTIONS ARE SHOWN ON FIG. 7. 3 (SHEET 2)

TRIGGER AND SWEEP GENERATOR (SWEEP GENERATOR AND CRT) FIG. 7. 3 (SHEET 3)

NOTES.

1. THOSE PARTS OF THIS CIRCUIT DIAGRAM WHICH ARE SHOWN IN BROKEN LINE ARE NOT PART OF THIS SUB-ASSEMBLY AND ARE SHOWN FOR CLARITY ONLY
2. POWER SUPPLY CONNECTIONS ARE SHOWN ON FIG. 7.3 (SHEET 2)
3. TAG LOCATION DIAGRAM OF SG IS SHOWN ON FIG. 7.3 (SHEET 1)

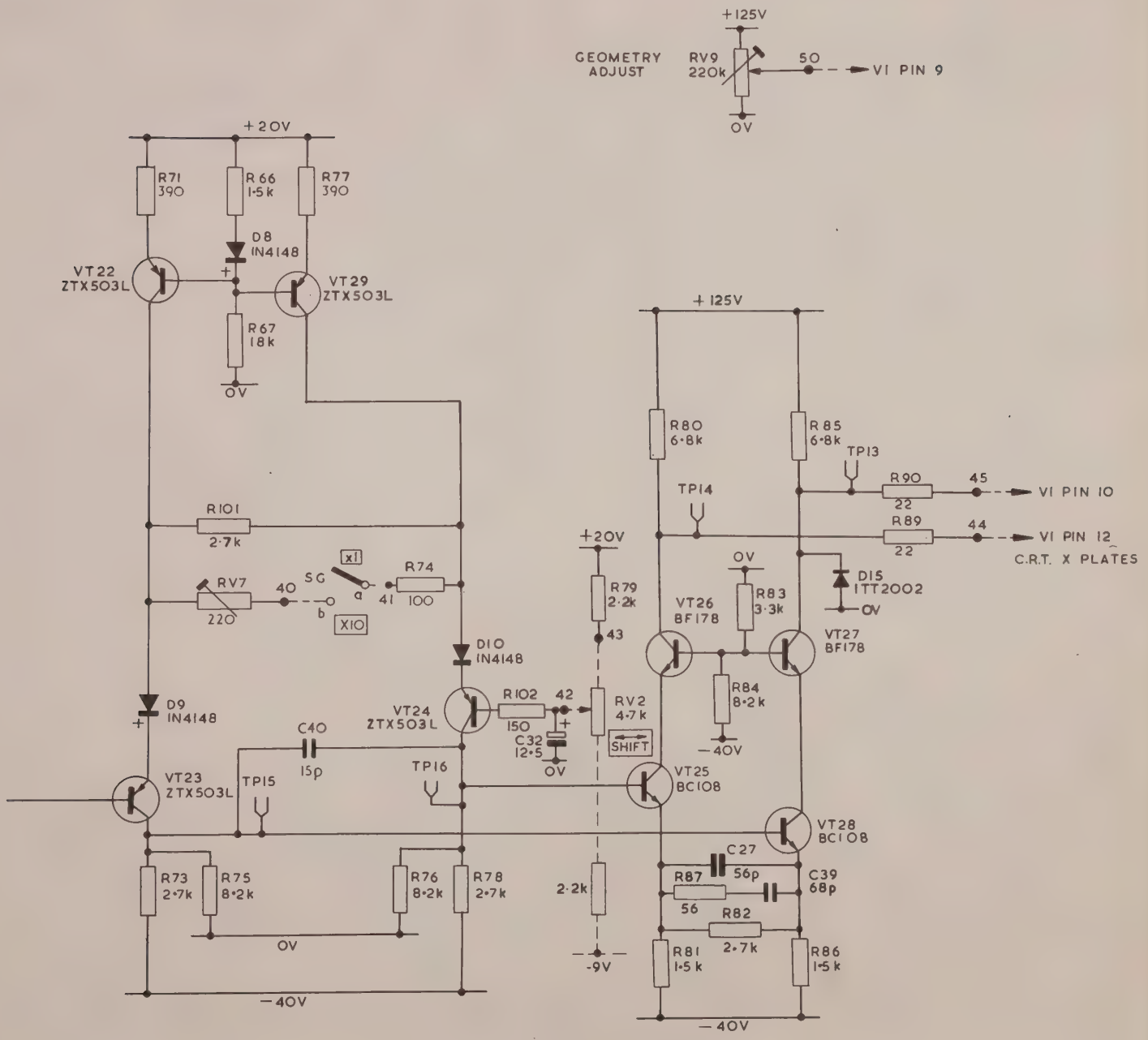


FIG. 7.3 (SHEET 4) TRIGGER AND SWEEP GENERATOR (X AMPLIFIER)

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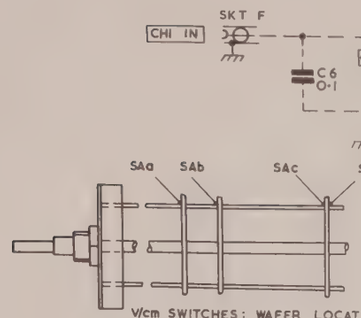
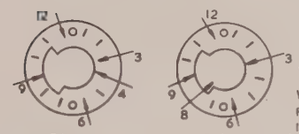
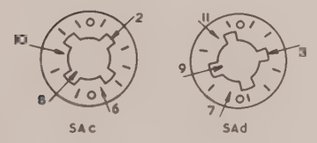
NOTES: 1. THOSE PARTS OF THIS CIRCUIT DIAGRAM WHICH ARE SHOWN IN BROKEN LINE ARE NOT PART OF THESE SUB-ASSEMBLIES AND ARE SHOWN FOR CLARITY ONLY.
2. TAG LOCATION DIAGRAMS OF SWITCHES SN AND SP ARE SHOWN ON FIG.7.2 (SHEET 2)
3. 5RV1 AND 6RV1 ARE ALSO SHOWN, FOR CLARITY, ON THE CIRCUIT DIAGRAM OF THE VERTICAL AMPLIFIER, X3 (CH1 AND CH2 PRE-AMPLIFIERS)



V/cm SWITCHES: WAFER LOCATION DIAGRAM

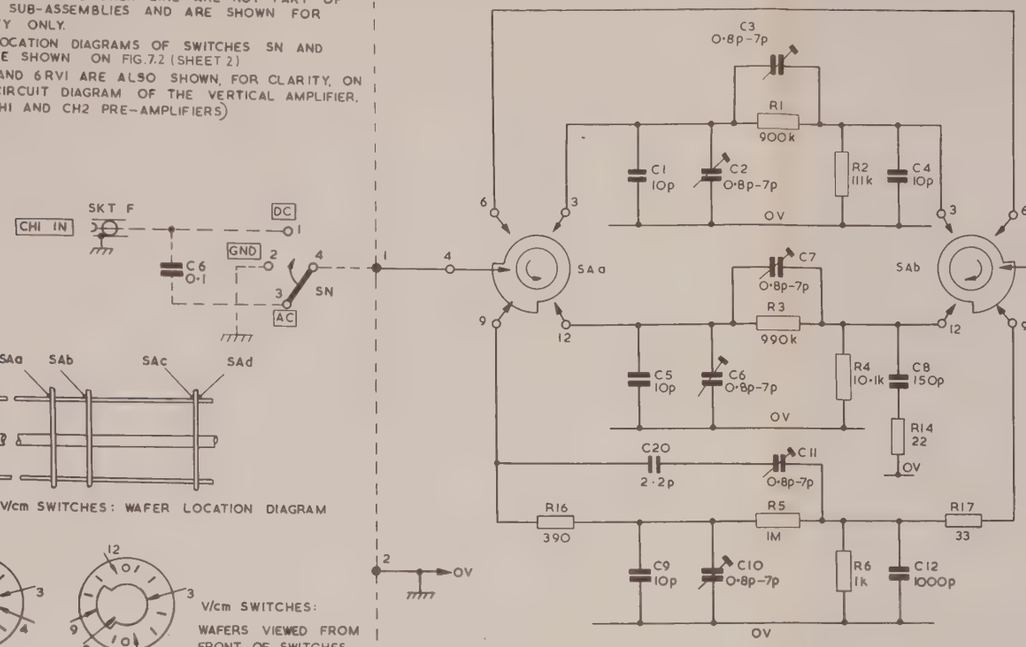


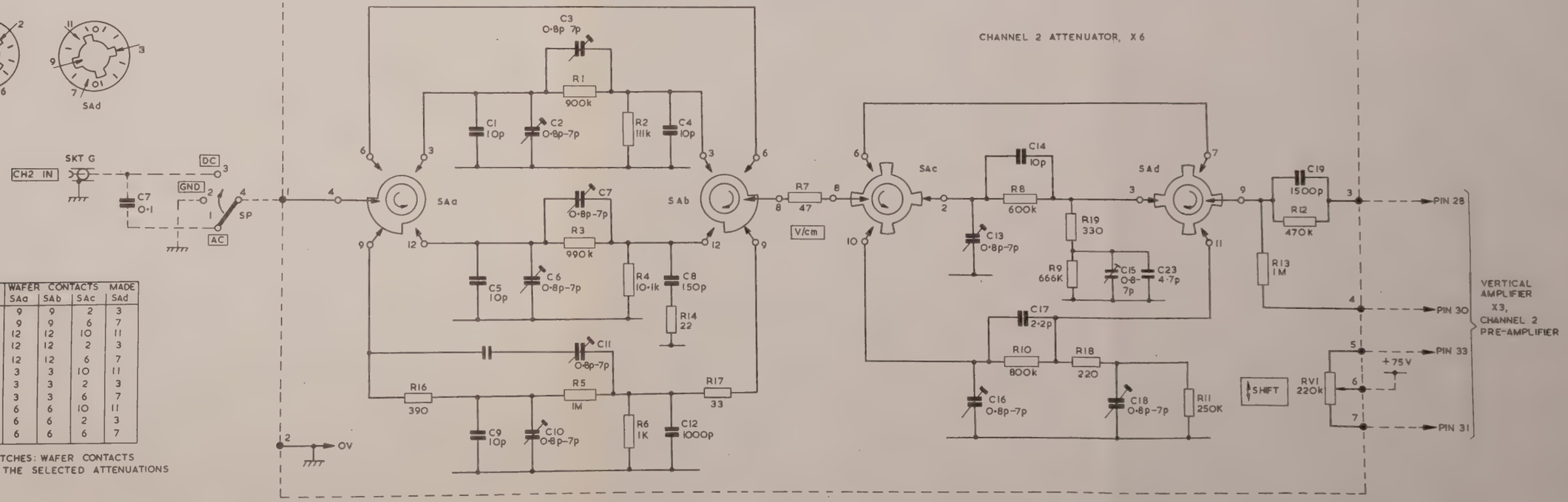
V/cm SWITCHES:
WAFERS VIEWED FROM FRONT OF SWITCHES IN EXTREME COUNTER CLOCKWISE POSITION



V/cm SELECTED	WAFER CONTACTS MADE SAa	SAb	SAc	SAd
50	9	9	2	3
20	9	9	6	7
10	12	12	10	11
5	12	12	2	3
2	12	12	6	7
1	3	3	10	11
0·5	3	3	2	3
0·2	3	3	6	7
0·1	6	6	10	11
0·05	6	6	2	3
0·02	6	6	6	7

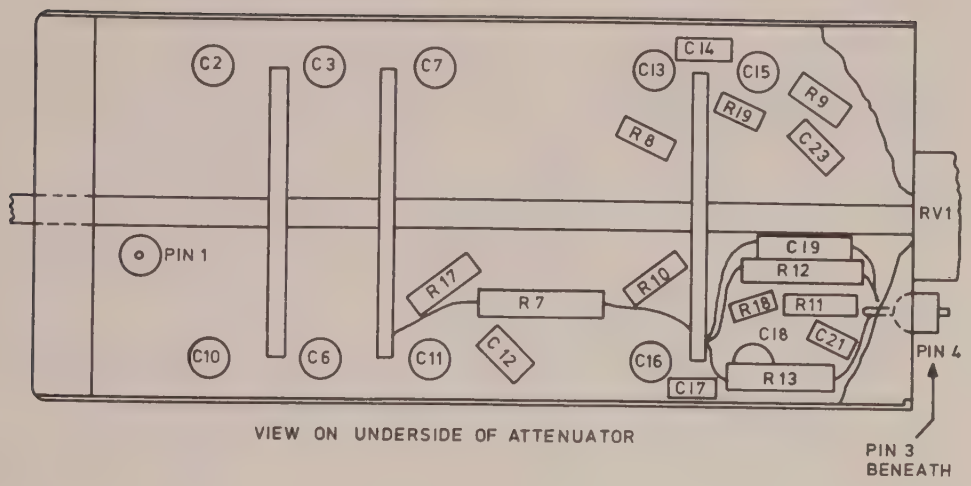
V/cm SWITCHES: WAFER CONTACTS MADE ON THE SELECTED ATTENUATIONS

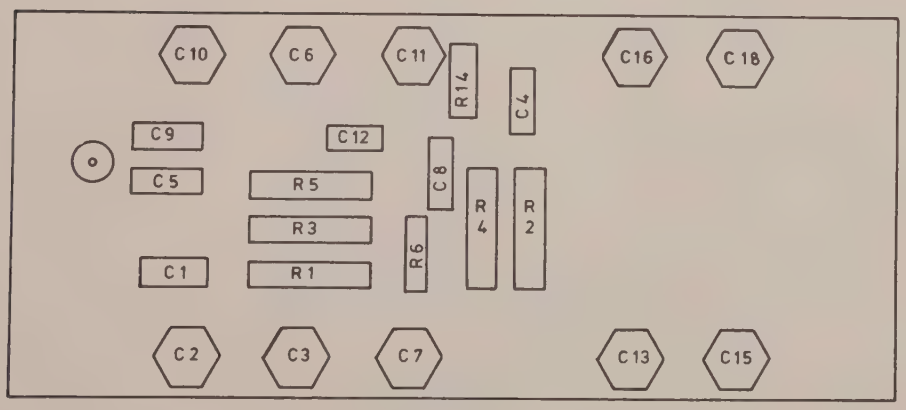




CM1004

ATTENUATORS X5 AND X6 (CHANNELS 1 AND 2) FIG.7.4 (SHEET 1)

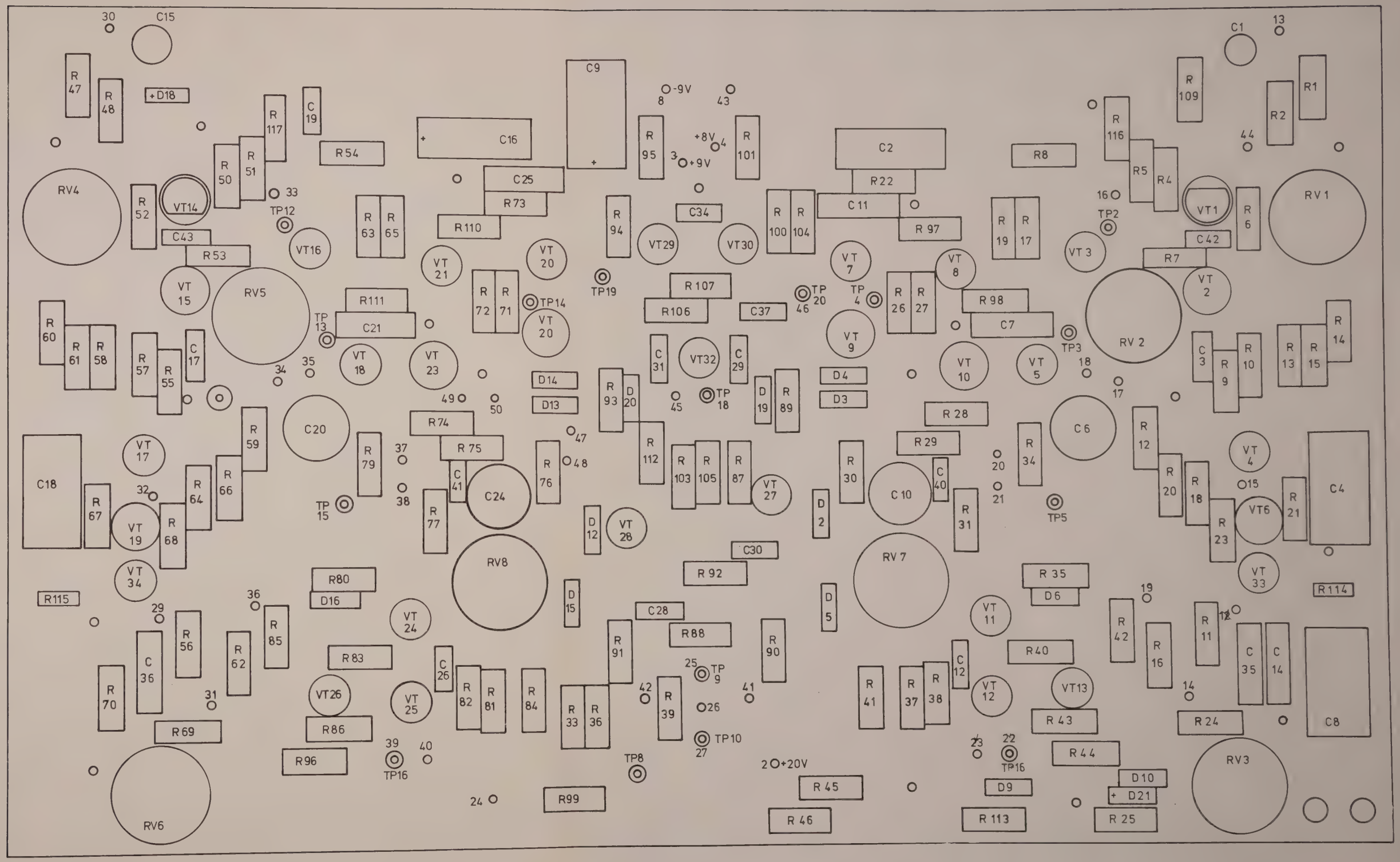




ATTENUATORS X5 AND X6-COMPONENT LAYOUT

FIG. 7-4. (SHEET 2.)

CM. 1004



Y-AMPLIFIER X3 - COMPONENT LAYOUT

FIG.7.5 (SHEET 1)

CM1004

NOTES. 1. THOSE PARTS OF THIS CIRCUIT DIAGRAM WHICH ARE SHOWN IN BROKEN LINE ARE NOT PART OF THIS SUB-ASSEMBLY AND ARE SHOWN FOR CLARITY ONLY.

2. TAG LOCATION DIAGRAMS OF SWITCHES SJ SK AND SL ARE SHOWN ON FIG. 7.2 (SHEET 2)

CHANNEL 1 PRE-AMPLIFIER

CHANNEL 1 TRIGGER AMPLIFIER

CHANNEL 2 PRE-AMPLIFIER

CHANNEL 2 TRIGGER AMPLIFIER

FIG. 7.5 (SHEET 2) Y-AMPLIFIER X3

CM1004

NOTES. 1. THOSE PARTS OF THIS CIRCUIT DIAGRAM WHICH ARE SHOWN IN BROKEN LINE ARE NOT PART OF THESE SUB-ASSEMBLIES AND ARE SHOWN FOR CLARITY ONLY.

2. TAG LOCATION DIAGRAMS OF SWITCH SM ARE SHOWN ON FIG. 7.2 (SHEET 2)

3. CONNECTIONS TO THE 'CHOP' AND 'ALT' POSITIONS OF SMd ARE SHOWN ON FIG. 7.2 (SHEET 2)

4. POWER SUPPLY CONNECTIONS ARE SHOWN ON FIG. 7.2 (SHEET 2)

ALTERNATE TRIGGER IN

CHOPPED BLANKING OUT

CHOP OSCILLATOR

SM—VERTICAL MODE

VERTICAL MODE BISTABLE

COMBINING AND SELECTING GATES

DELAY LINE

VERTICAL OUTPUT AMPLIFIER, X4

PIN 8

PIN 7 C.R.T. Y PLATES

SEE NOTE 3

CM. 1004

Y-AMPLIFIER X3 (VERTICAL OUTPUT AMPLIFIER X4)

FIG. 7.5. (SHEET 3).

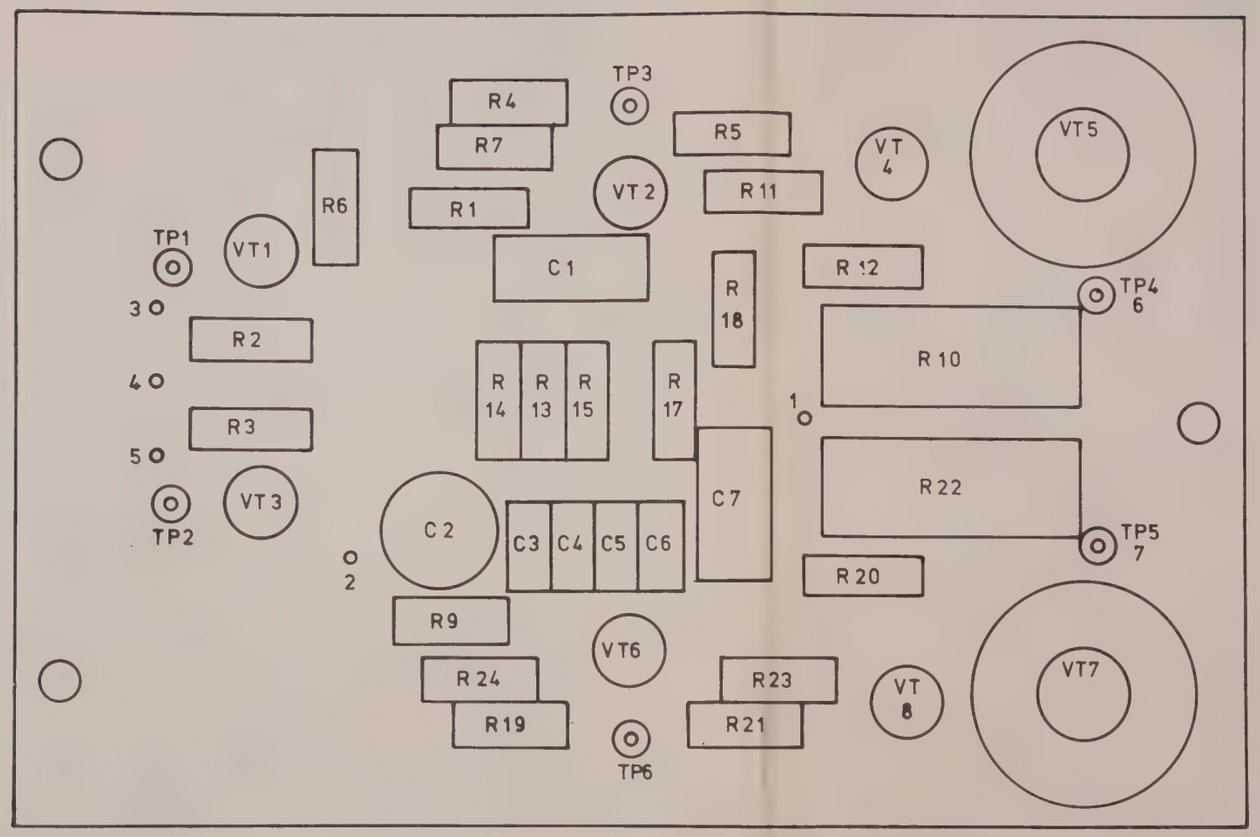
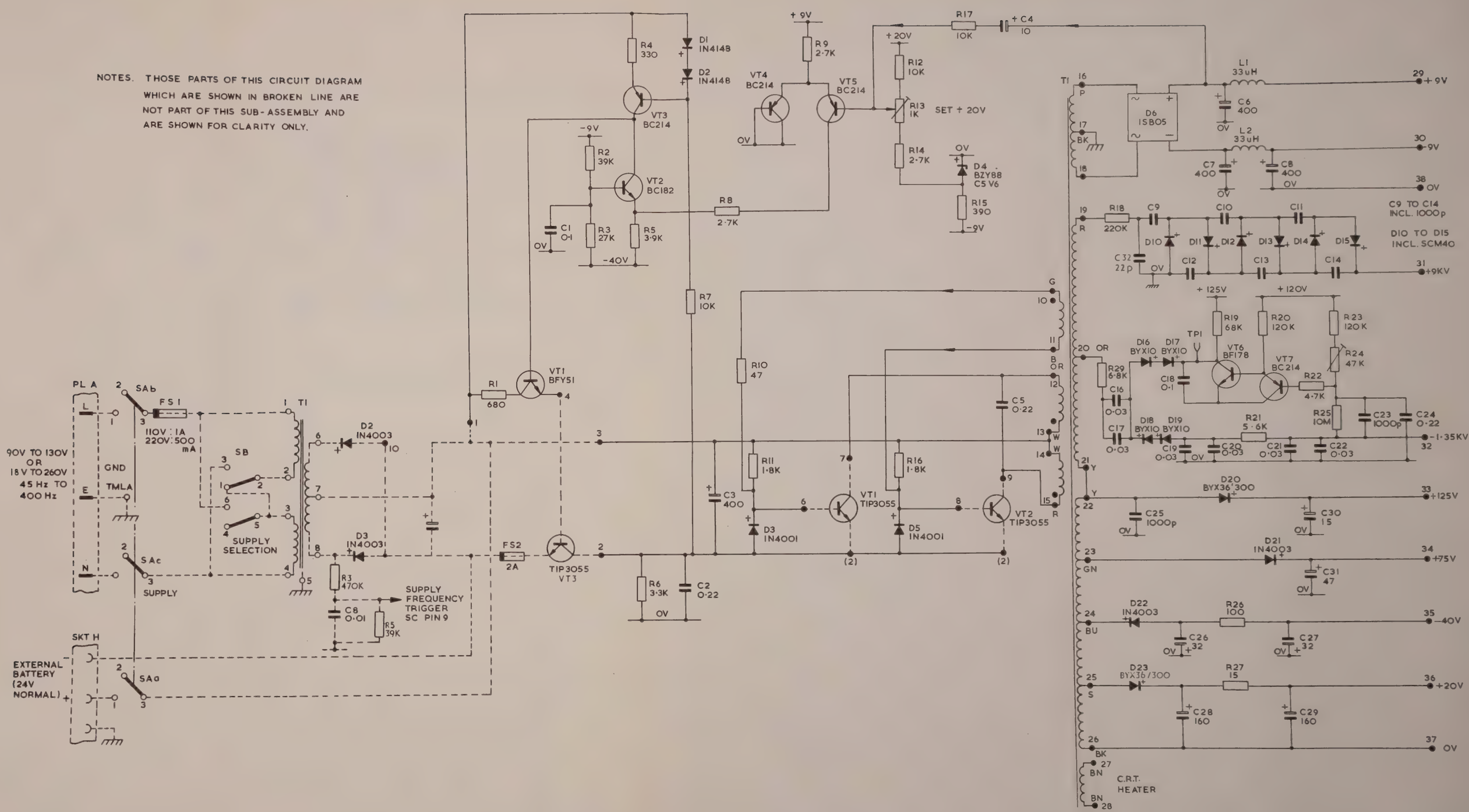


FIG. 7.5 (SHEET 4). VERTICAL OUTPUT AMPLIFIER X4 - COMPONENT LAYOUT CM 1004.

NOTES. THOSE PARTS OF THIS CIRCUIT DIAGRAM WHICH ARE SHOWN IN BROKEN LINE ARE NOT PART OF THIS SUB-ASSEMBLY AND ARE SHOWN FOR CLARITY ONLY.



POWER SUPPLY UNIT X1. FIG. 7.6 (SHEET 1)

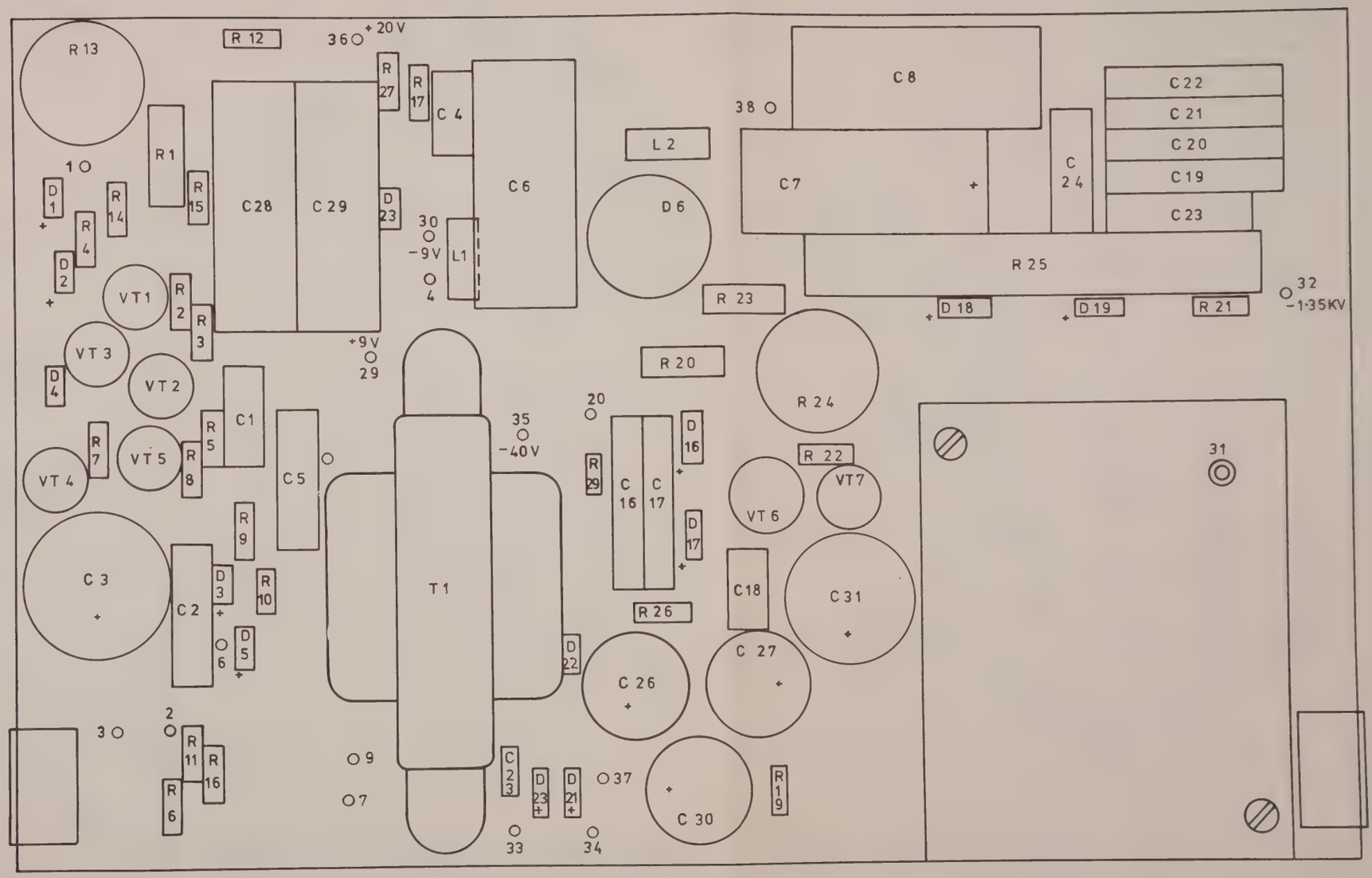
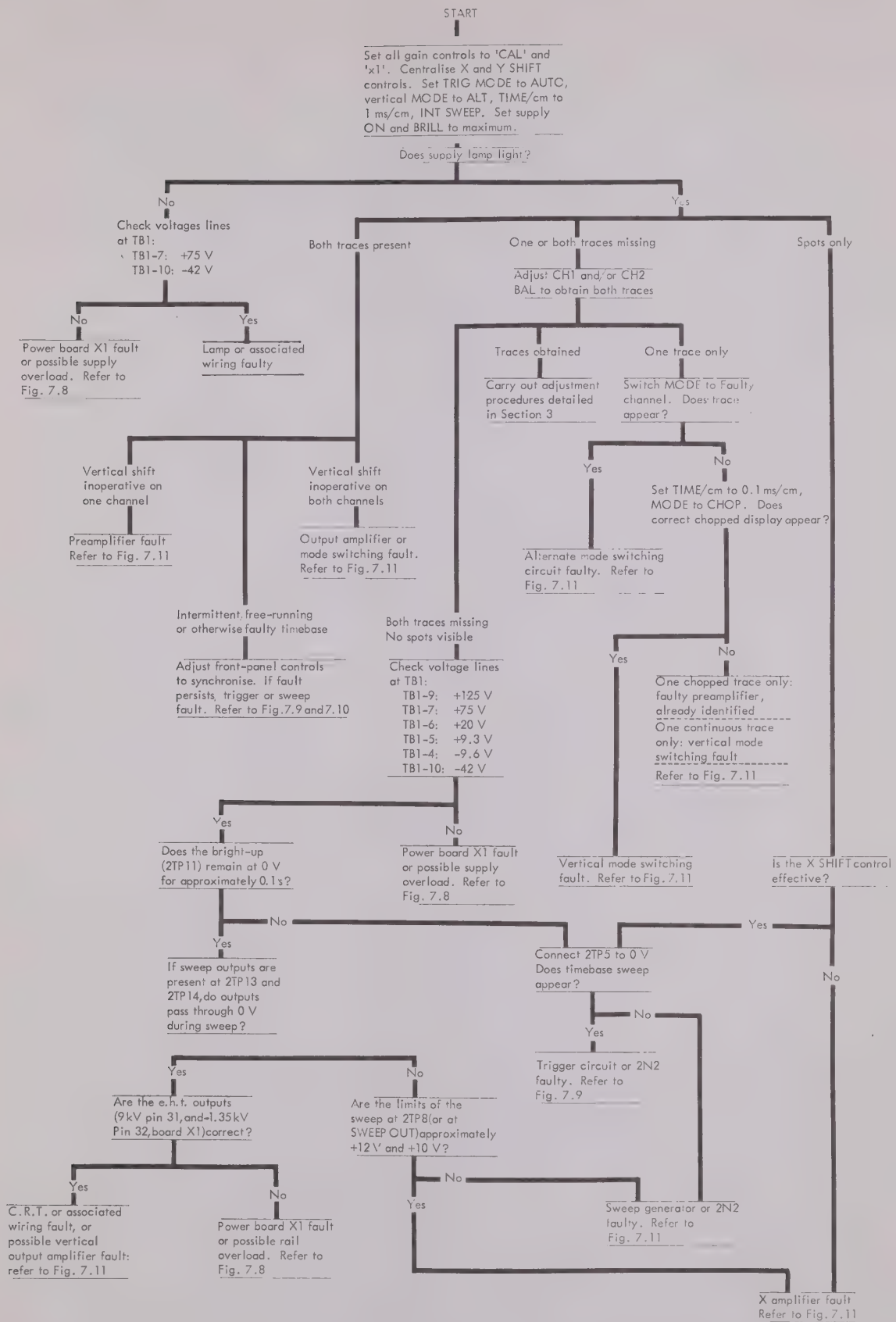


FIG. 7.6 (SHEET 2)

POWER SUPPLY UNIT X1 - COMPONENT LAYOUT

CM.1004


START
Set all gain controls to 'CAL' and 'x1'. Centralise X and Y SHIFT controls. Set TRIG MODE to AUTO, vertical MODE to ALT, TIME/cm to 1 ms/cm, INT SWEEP. Set supply ON and BRILL to maximum.
Does supply lamp light?
No
Yes
Check voltages lines at TB1:
TB1-7: +75 V
TB1-10: -42 V
No
Yes
Power board X1 fault or possible supply overload. Refer to Fig. 7.8
Lamp or associated wiring faulty
Both traces present
One or both traces missing
Spots only
Adjust CH1 and/or CH2 BAL to obtain both traces
Traces obtained
One trace only
Carry out adjustment procedures detailed in Section 3
Switch MODE to Faulty channel. Does trace appear?
Yes
No
Set TIME/cm to 0.1 ms/cm, MODE to CHOP. Does correct chopped display appear?
Alternate mode switching circuit faulty. Refer to Fig. 7.11
Yes
No
One chopped trace only: faulty preamplifier, already identified
One continuous trace only: vertical mode switching fault
Refer to Fig. 7.11
Vertical mode switching fault. Refer to Fig. 7.11
Is the X SHIFT control effective?
Yes
No
Vertical shift inoperative on one channel
Preamplifier fault Refer to Fig. 7.11
Vertical shift inoperative on both channels
Output amplifier or mode switching fault. Refer to Fig. 7.11
Intermittent, free-running or otherwise faulty timebase
Adjust front-panel controls to synchronise. If fault persists, trigger or sweep fault. Refer to Fig. 7.9 and 7.10
Both traces missing
No spots visible
Check voltage lines at TB1:
TB1-9: +125 V
TB1-7: +75 V
TB1-6: +20 V
TB1-5: +9.3 V
TB1-4: -9.6 V
TB1-10: -42 V
Yes
No
Does the bright-up (2TP11) remain at 0 V for approximately 0.1 s?
Power board X1 fault or possible supply overload. Refer to Fig. 7.8
Yes
No
If sweep outputs are present at 2TP13 and 2TP14, do outputs pass through 0 V during sweep?
Connect 2TP5 to 0 V Does timebase sweep appear?
Yes
No
Trigger circuit or 2N2 faulty. Refer to Fig. 7.9
Yes
No
Are the e.h.t. outputs (9 kV pin 31, and -1.35 kV Pin 32, board X1) correct?
Are the limits of the sweep at 2TP8 (or at SWEEP OUT) approximately +12 V and +10 V?
Yes
No
C.R.T. or associated wiring fault, or possible vertical output amplifier fault: refer to Fig. 7.11
Power board X1 fault or possible rail overload. Refer to Fig. 7.8
No
Yes
Sweep generator or 2N2 faulty. Refer to Fig. 7.11
X amplifier fault Refer to Fig. 7.11

CM.1004

FIG. 7-7 MASTER TROUBLESHOOTING CHART

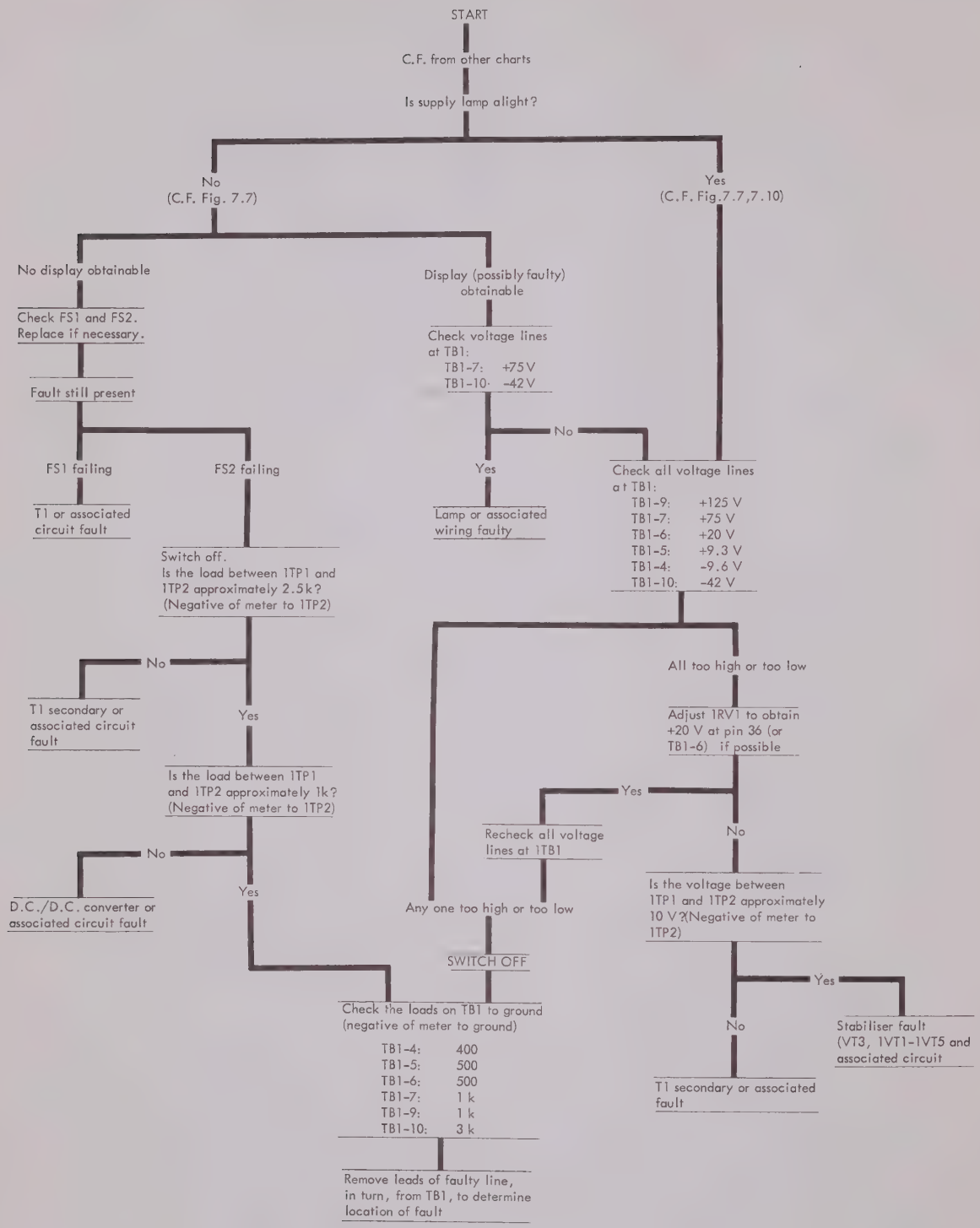
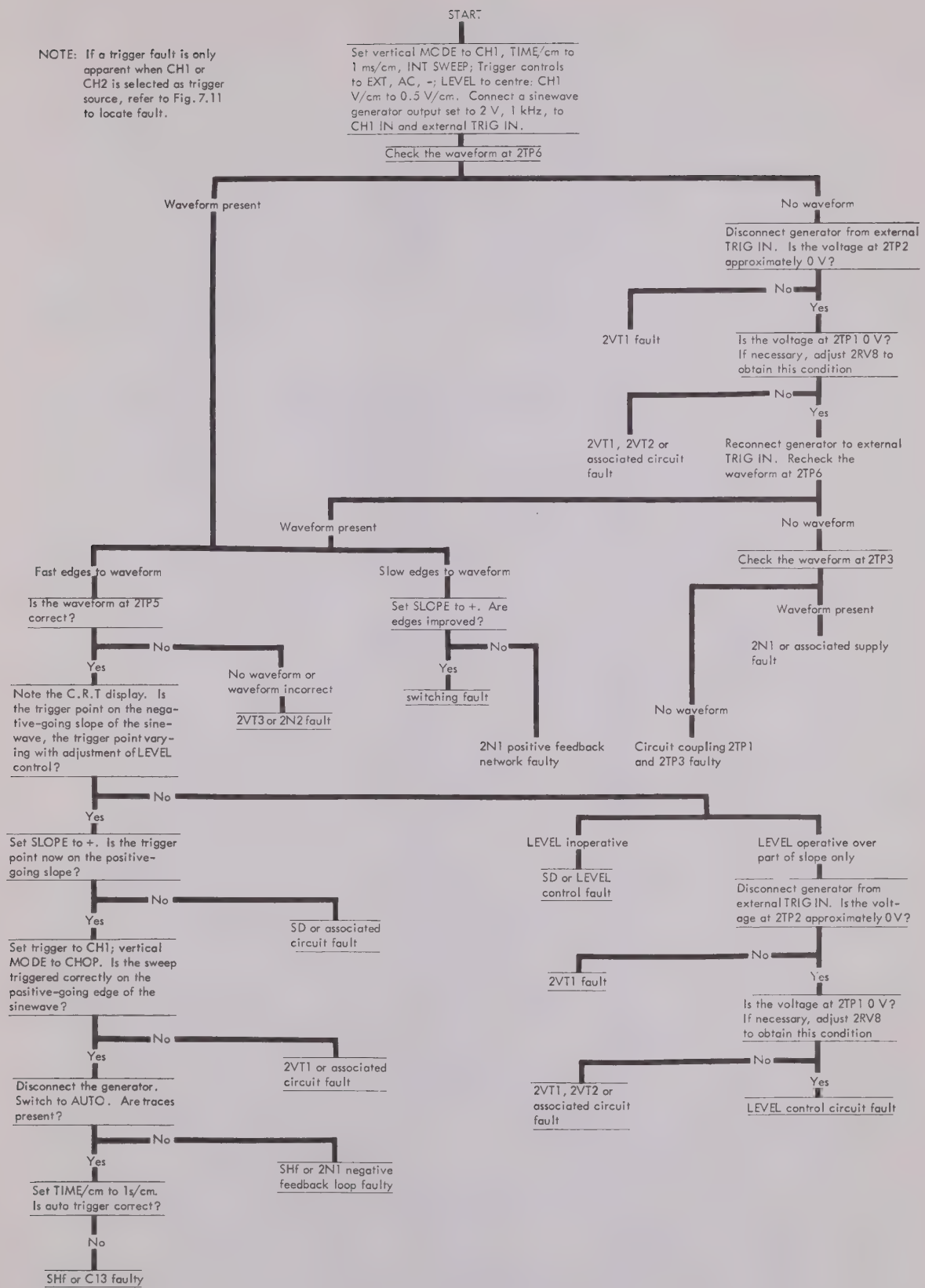

START
C.F. from other charts
Is supply lamp alight?
No
(C.F. Fig. 7.7)
Yes
(C.F. Fig.7.7,7.10)
No display obtainable
Check FS1 and FS2. Replace if necessary.
Fault still present
FS1 failing
T1 or associated circuit fault
FS2 failing
Switch off. Is the load between 1TP1 and 1TP2 approximately 2.5k? (Negative of meter to 1TP2)
No
T1 secondary or associated circuit fault
Yes
Is the load between 1TP1 and 1TP2 approximately 1k? (Negative of meter to 1TP2)
No
D.C./D.C. converter or associated circuit fault
Yes
Display (possibly faulty) obtainable
Check voltage lines at TB1:
TB1-7: +75V
TB1-10: -42V
No
Yes
Lamp or associated wiring faulty
Check all voltage lines at TB1:
TB1-9: +125 V
TB1-7: +75 V
TB1-6: +20 V
TB1-5: +9.3 V
TB1-4: -9.6 V
TB1-10: -42 V
All too high or too low
Adjust 1RV1 to obtain +20 V at pin 36 (or TB1-6) if possible
Yes
Recheck all voltage lines at 1TB1
No
Is the voltage between 1TP1 and 1TP2 approximately 10 V?(Negative of meter to 1TP2)
Yes
Stabiliser fault (VT3, 1VT1-1VT5 and associated circuit
No
T1 secondary or associated fault
Any one too high or too low
SWITCH OFF
Check the loads on TB1 to ground (negative of meter to ground)
TB1-4: 400
TB1-5: 500
TB1-6: 500
TB1-7: 1 k
TB1-9: 1 k
TB1-10: 3 k
Remove leads of faulty line, in turn, from TB1, to determine location of fault

FIG. 7-8 POWER SUPPLY UNIT X1 - TROUBLESHOOTING CHART

CM.1004


START
NOTE: If a trigger fault is only apparent when CH1 or CH2 is selected as trigger source, refer to Fig. 7.11 to locate fault.
Set vertical MODE to CH1, TIME/cm to 1 ms/cm, INT SWEEP; Trigger controls to EXT, AC, -; LEVEL to centre: CH1 V/cm to 0.5 V/cm. Connect a sinewave generator output set to 2 V, 1 kHz, to CH1 IN and external TRIG IN.
Check the waveform at 2TP6
Waveform present
No waveform
Disconnect generator from external TRIG IN. Is the voltage at 2TP2 approximately 0 V?
No
Yes
2VT1 fault
Is the voltage at 2TP1 0 V? If necessary, adjust 2RV8 to obtain this condition
No
Yes
2VT1, 2VT2 or associated circuit fault
Reconnect generator to external TRIG IN. Recheck the waveform at 2TP6
Waveform present
No waveform
Check the waveform at 2TP3
Waveform present
2N1 or associated supply fault
Fast edges to waveform
Slow edges to waveform
Is the waveform at 2TP5 correct?
Set SLOPE to +. Are edges improved?
No
Yes
No waveform or waveform incorrect
2VT3 or 2N2 fault
No
Yes
switching fault
2N1 positive feedback network faulty
No waveform
Circuit coupling 2TP1 and 2TP3 faulty
Note the C.R.T display. Is the trigger point on the negative-going slope of the sinewave, the trigger point varying with adjustment of LEVEL control?
No
Yes
Set SLOPE to +. Is the trigger point now on the positive-going slope?
No
Yes
SD or associated circuit fault
Set trigger to CH1; vertical MODE to CHOP. Is the sweep triggered correctly on the positive-going edge of the sinewave?
No
Yes
2VT1 or associated circuit fault
Disconnect the generator. Switch to AUTO. Are traces present?
No
Yes
SHf or 2N1 negative feedback loop faulty
Set TIME/cm to 1s/cm. Is auto trigger correct?
No
SHf or C13 faulty
LEVEL inoperative
SD or LEVEL control fault
LEVEL operative over part of slope only
Disconnect generator from external TRIG IN. Is the voltage at 2TP2 approximately 0 V?
No
Yes
2VT1 fault
Is the voltage at 2TP1 0 V? If necessary, adjust 2RV8 to obtain this condition
No
Yes
2VT1, 2VT2 or associated circuit fault
LEVEL control circuit fault

CM.1004

FIG. 7-9 TRIGGER GENERATOR X2 - TROUBLESHOOTING CHART

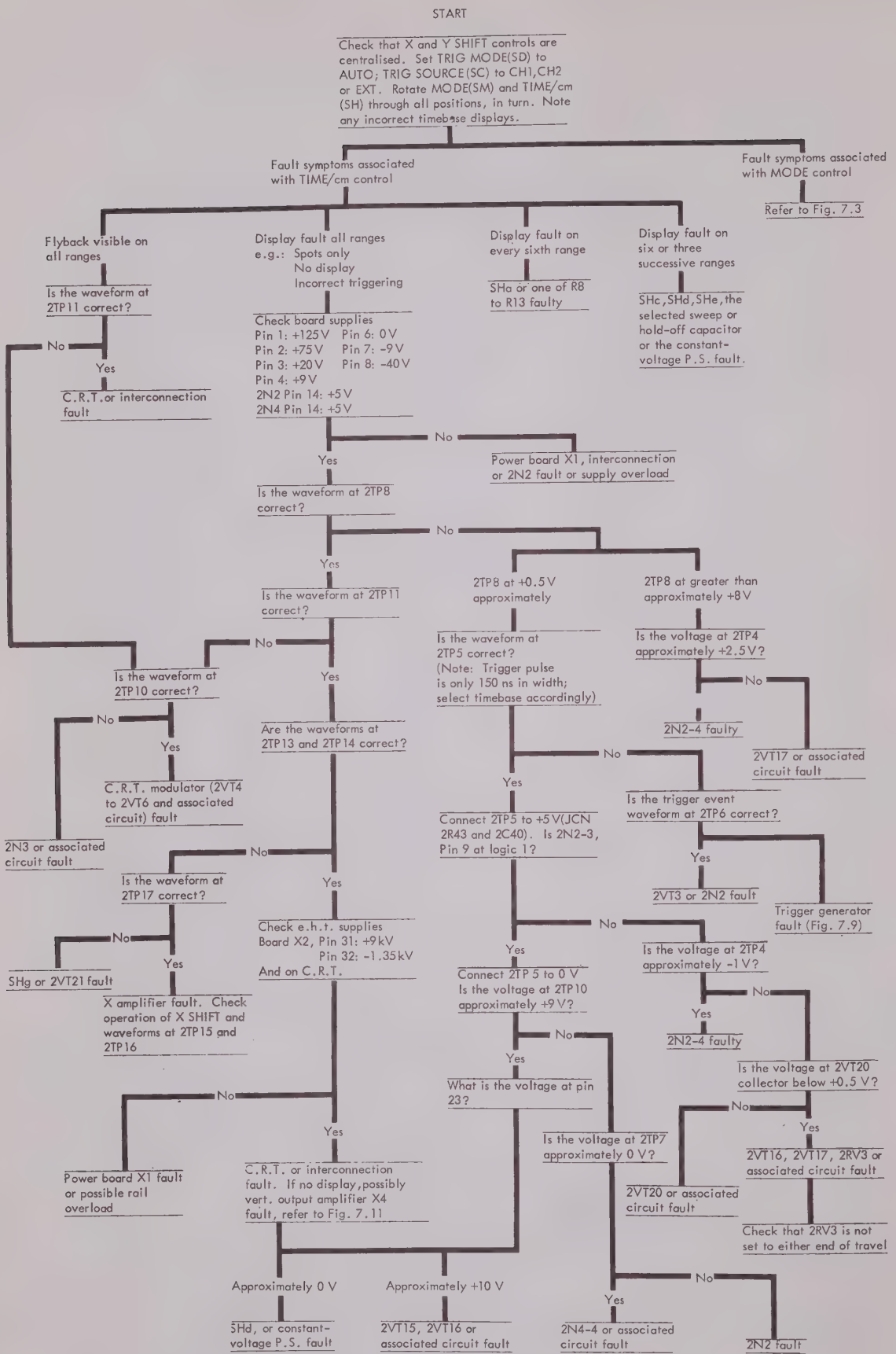

START
Check that X and Y SHIFT controls are centralised. Set TRIG MODE(SD) to AUTO; TRIG SOURCE(SC) to CH1, CH2 or EXT. Rotate MODE(SM) and TIME/cm (SH) through all positions, in turn. Note any incorrect timebase displays.
Fault symptoms associated with TIME/cm control
Fault symptoms associated with MODE control
Refer to Fig. 7.3
Flyback visible on all ranges
Display fault all ranges e.g.: Spots only No display Incorrect triggering
Display fault on every sixth range
Display fault on six or three successive ranges
SHa or one of R8 to R13 faulty
SHc, SHd, SHe, the selected sweep or hold-off capacitor or the constant-voltage P.S. fault.
Is the waveform at 2TP11 correct?
No
Yes
C.R.T. or interconnection fault
Check board supplies
Pin 1: +125 V Pin 6: 0 V
Pin 2: +75 V Pin 7: -9 V
Pin 3: +20 V Pin 8: -40 V
Pin 4: +9 V
2N2 Pin 14: +5 V
2N4 Pin 14: +5 V
No
Yes
Power board X1, interconnection or 2N2 fault or supply overload
Is the waveform at 2TP8 correct?
No
Yes
2TP8 at +0.5 V approximately
2TP8 at greater than approximately +8 V
Is the waveform at 2TP11 correct?
Is the waveform at 2TP5 correct? (Note: Trigger pulse is only 150 ns in width; select timebase accordingly)
Is the voltage at 2TP4 approximately +2.5 V?
No
Yes
2N2-4 faulty
2VT17 or associated circuit fault
Is the waveform at 2TP10 correct?
No
Yes
C.R.T. modulator (2VT4 to 2VT6 and associated circuit) fault
2N3 or associated circuit fault
Are the waveforms at 2TP13 and 2TP14 correct?
No
Yes
Connect 2TP5 to +5 V (JCN 2R43 and 2C40). Is 2N2-3, Pin 9 at logic 1?
No
Yes
Is the trigger event waveform at 2TP6 correct?
Yes
2VT3 or 2N2 fault
Trigger generator fault (Fig. 7.9)
Is the waveform at 2TP17 correct?
No
Yes
SHg or 2VT21 fault
X amplifier fault. Check operation of X SHIFT and waveforms at 2TP15 and 2TP16
Check e.h.t. supplies Board X2, Pin 31: +9 kV Pin 32: -1.35 kV And on C.R.T.
Connect 2TP 5 to 0 V Is the voltage at 2TP10 approximately +9 V?
No
Yes
Is the voltage at 2TP4 approximately -1 V?
No
Yes
2N2-4 faulty
Is the voltage at 2VT20 collector below +0.5 V?
No
Yes
2VT16, 2VT17, 2RV3 or associated circuit fault
2VT20 or associated circuit fault
Check that 2RV3 is not set to either end of travel
What is the voltage at pin 23?
Is the voltage at 2TP7 approximately 0 V?
No
Yes
2N4-4 or associated circuit fault
2N2 fault
No
Yes
Power board X1 fault or possible rail overload
C.R.T. or interconnection fault. If no display, possibly vert. output amplifier X4 fault, refer to Fig. 7.11
Approximately 0 V
Approximately +10 V
5Hd, or constant-voltage P.S. fault
2VT15, 2VT16 or associated circuit fault

FIG. 7-10 SWEEP GENERATOR AND X-AMPLIFIER, X2 - TROUBLESHOOTING CHART CM.1004

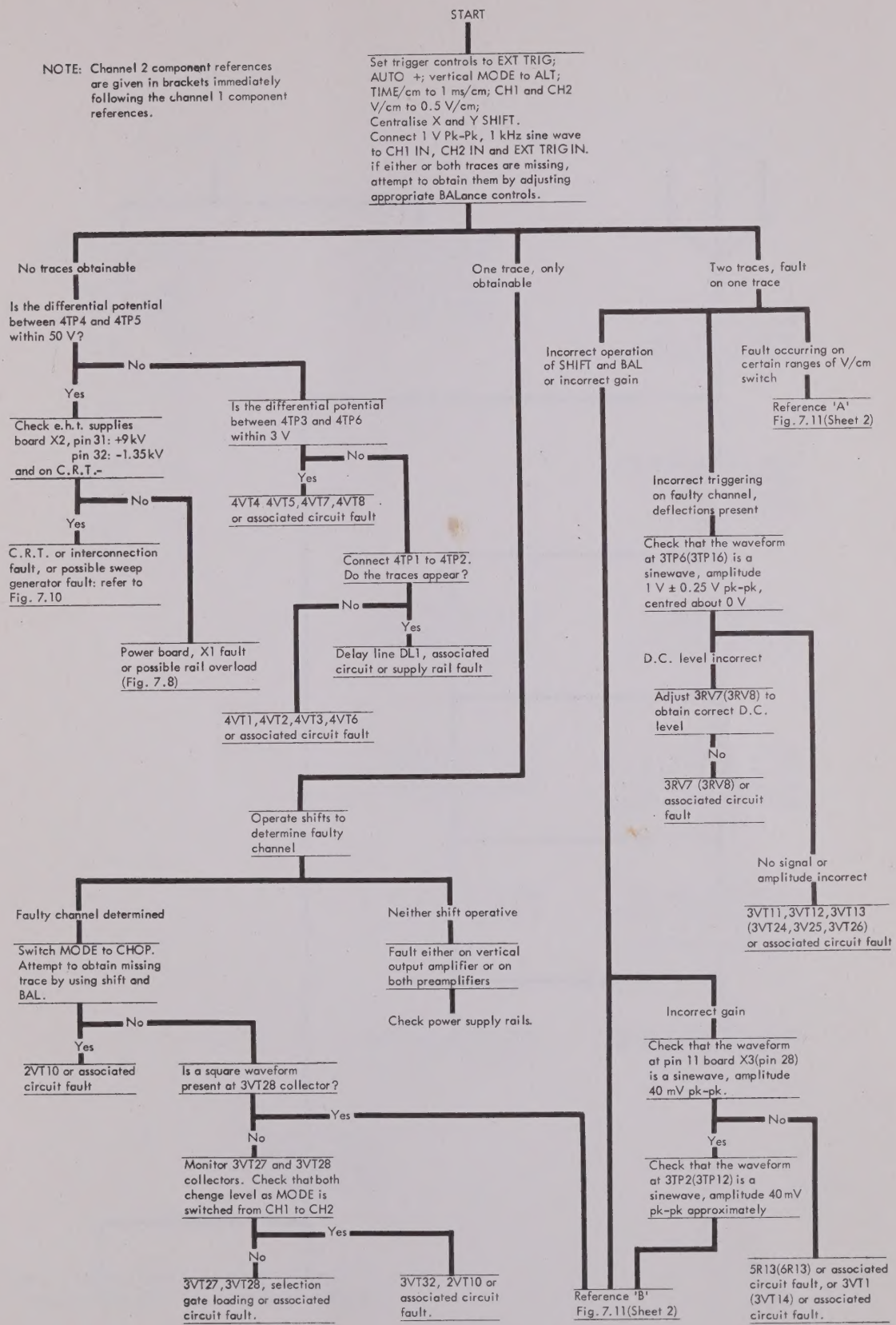

START
NOTE: Channel 2 component references are given in brackets immediately following the channel 1 component references.
Set trigger controls to EXT TRIG; AUTO +; vertical MODE to ALT; TIME/cm to 1 ms/cm; CH1 and CH2 V/cm to 0.5 V/cm; Centralise X and Y SHIFT. Connect 1 V Pk-Pk, 1 kHz sine wave to CH1 IN, CH2 IN and EXT TRIG IN. if either or both traces are missing, attempt to obtain them by adjusting appropriate BALance controls.
No traces obtainable
One trace, only obtainable
Two traces, fault on one trace
Is the differential potential between 4TP4 and 4TP5 within 50 V?
No
Yes
Check e.h.t. supplies board X2, pin 31: +9 kV pin 32: -1.35 kV and on C.R.T.-
No
Yes
C.R.T. or interconnection fault, or possible sweep generator fault: refer to Fig. 7.10
Power board, X1 fault or possible rail overload (Fig. 7.8)
Is the differential potential between 4TP3 and 4TP6 within 3 V
No
Yes
4VT4 4VT5, 4VT7, 4VT8 or associated circuit fault
Connect 4TP1 to 4TP2. Do the traces appear?
No
Yes
Delay line DL1, associated circuit or supply rail fault
4VT1, 4VT2, 4VT3, 4VT6 or associated circuit fault
Operate shifts to determine faulty channel
Faulty channel determined
Switch MODE to CHOP. Attempt to obtain missing trace by using shift and BAL.
No
Yes
2VT10 or associated circuit fault
Is a square waveform present at 3VT28 collector?
Yes
No
Monitor 3VT27 and 3VT28 collectors. Check that both chenge level as MODE is switched from CH1 to CH2
Yes
No
3VT27, 3VT28, selection gate loading or associated circuit fault.
3VT32, 2VT10 or associated circuit fault.
Neither shift operative
Fault either on vertical output amplifier or on both preamplifiers
Check power supply rails.
Incorrect operation of SHIFT and BAL or incorrect gain
Reference 'B' Fig. 7.11(Sheet 2)
Fault occurring on certain ranges of V/cm switch
Reference 'A' Fig. 7.11(Sheet 2)
Incorrect triggering on faulty channel, deflections present
Check that the waveform at 3TP6(3TP16) is a sinewave, amplitude 1 V ± 0.25 V pk-pk, centred about 0 V
D.C. level incorrect
Adjust 3RV7(3RV8) to obtain correct D.C. level
No
3RV7 (3RV8) or associated circuit fault
No signal or amplitude incorrect
3VT11, 3VT12, 3VT13 (3VT24, 3VT25, 3VT26) or associated circuit fault
Incorrect gain
Check that the waveform at pin 11 board X3(pin 28) is a sinewave, amplitude 40 mV pk-pk.
No
Yes
Check that the waveform at 3TP2(3TP12) is a sinewave, amplitude 40 mV pk-pk approximately
5R13(6R13) or associated circuit fault, or 3VT1 (3VT14) or associated circuit fault.

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FIG. 7-11 VERTICAL DEFLECTION SYSTEM (SHEET 1)

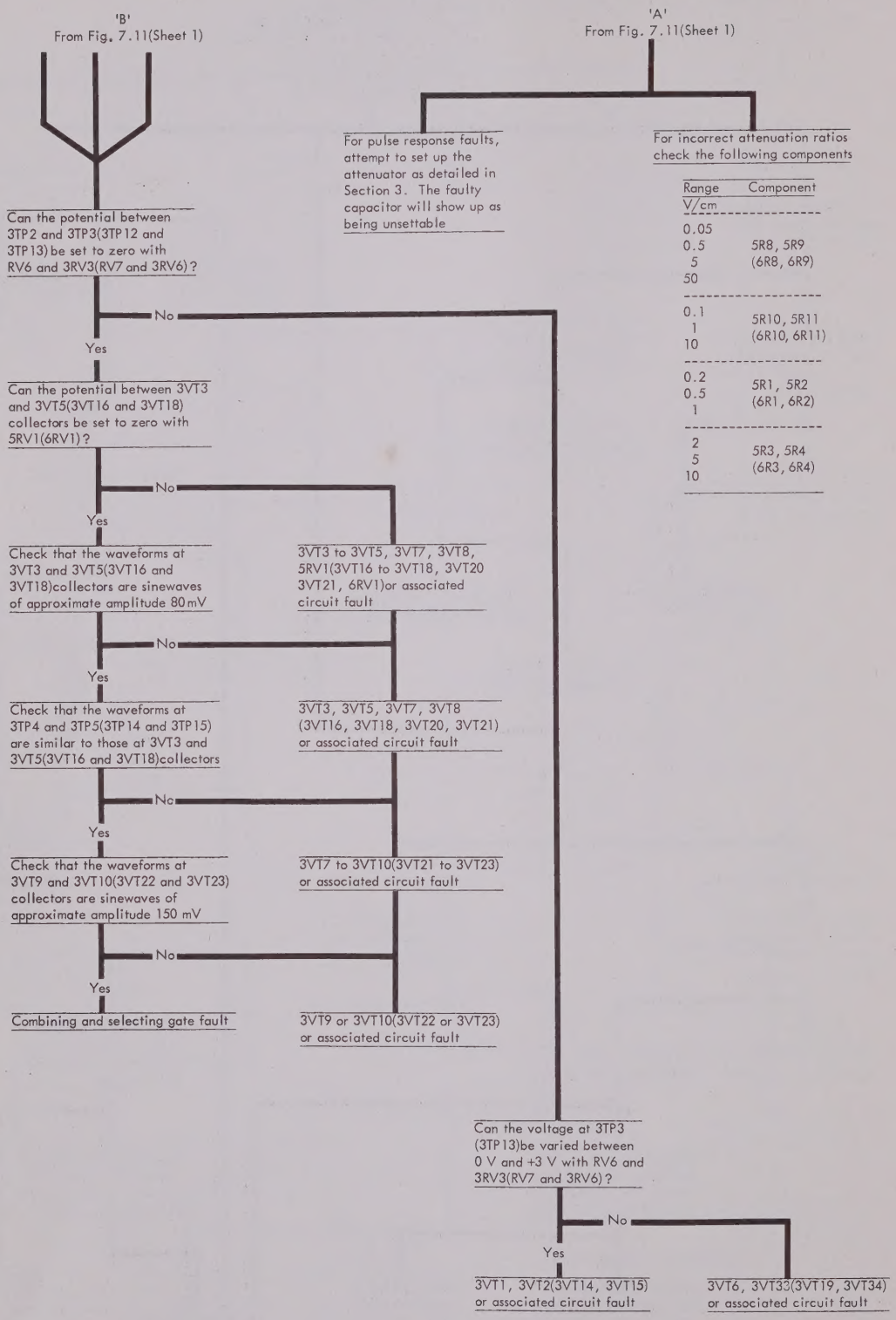
'B'
From Fig. 7.11(Sheet 1)
'A'
From Fig. 7.11(Sheet 1)
For pulse response faults, attempt to set up the attenuator as detailed in Section 3. The faulty capacitor will show up as being unsettable
For incorrect attenuation ratios check the following components
Range V/cm
Component
0.05
0.5
5
50
5R8, 5R9 (6R8, 6R9)
0.1
1
10
5R10, 5R11 (6R10, 6R11)
0.2
0.5
1
5R1, 5R2 (6R1, 6R2)
2
5
10
5R3, 5R4 (6R3, 6R4)
Can the potential between 3TP2 and 3TP3(3TP12 and 3TP13) be set to zero with RV6 and 3RV3(RV7 and 3RV6)?
No
Yes
Can the potential between 3VT3 and 3VT5(3VT16 and 3VT18) collectors be set to zero with 5RV1(6RV1)?
No
Yes
3VT3 to 3VT5, 3VT7, 3VT8, 5RV1(3VT16 to 3VT18, 3VT20 3VT21, 6RV1)or associated circuit fault
Check that the waveforms at 3VT3 and 3VT5(3VT16 and 3VT18)collectors are sinewaves of approximate amplitude 80 mV
No
Yes
3VT3, 3VT5, 3VT7, 3VT8 (3VT16, 3VT18, 3VT20, 3VT21) or associated circuit fault
Check that the waveforms at 3TP4 and 3TP5(3TP14 and 3TP15) are similar to those at 3VT3 and 3VT5(3VT16 and 3VT18)collectors
No
Yes
3VT7 to 3VT10(3VT21 to 3VT23) or associated circuit fault
Check that the waveforms at 3VT9 and 3VT10(3VT22 and 3VT23) collectors are sinewaves of approximate amplitude 150 mV
No
Yes
3VT9 or 3VT10(3VT22 or 3VT23) or associated circuit fault
Combining and selecting gate fault
Can the voltage at 3TP3 (3TP13)be varied between 0 V and +3 V with RV6 and 3RV3(RV7 and 3RV6)?
No
Yes
3VT1, 3VT2(3VT14, 3VT15) or associated circuit fault
3VT6, 3VT33(3VT19, 3VT34) or associated circuit fault

FIG. 7-11 VERTICAL DEFLECTION SYSTEM (SHEET 2) CM.1004

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